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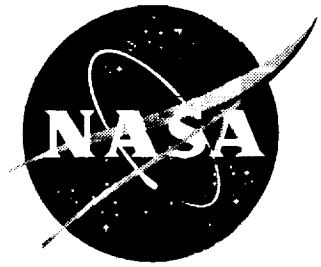

Yawed-Rolling Tire Mechanical Properties Testing of the Navy T-45 Aircraft Tires

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March 2000

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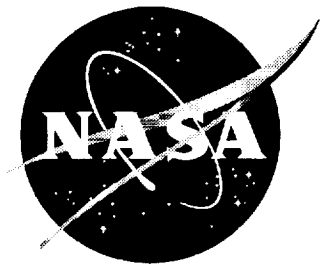

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YAWED-ROLLING TIRE MECHANICAL PROPERTIES TESTING OF THE NAVY T-45 AIRCRAFT TIRES

Robert H. Daugherty
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ABSTRACT

The T-45 Goshawk is a United States Navy jet aircraft used primarily as a trainer. The aircraft design makes use of "off the shelf" hardware as much as possible and was found to have unusual directional control issues during ground operations. The aircraft was involved in numerous pilot-induced-oscillation incidents as well as observed to have unusual directional control reactions to failed main gear tires, a condition that is normally handled relatively easily by conventional aircraft steering control techniques. The behavior of the aircraft's tires had previously been modeled in simulators as a result of approximations provided in 40-year-old reference publications. Since knowledge of the true tire cornering and braking behavior is essential to modeling, understanding, and fixing directional control problems, the United States Navy requested assistance from the NASA Langley Research Center's (LaRC) Aircraft Landing Dynamics Facility (ALDF) to define the yawed-rolling mechanical properties of the T-45 aircraft tires. The purpose of this report is to document the results of testing the subject tires at the NASA LaRC ALDF in September 1998. Brief descriptions of the Instrumented Tire Test Vehicle (ITTV) are included to familiarize the reader with the ITTV capabilities, data acquisition system, test and measurement techniques, data accuracy, and analysis and presentation of the testing results.

FACILITY CAPABILITIES

The ITTV consists of an approximately 28000 lb. truck to which is attached a pneumatically driven test fixture loading system. A specially designed force measurement dynamometer allows for a variety of aircraft and automotive type components, especially tires, to be mounted in the test fixture. Forces and moments associated with yawed or braking rolling conditions such as vertical load, drag load, side load, yaw angle, aligning torque, overturning torque, and speed configurations are measured and recorded by an onboard electronic data acquisition system. Continuous time histories are taken by appropriately placed strain gages for each test run. For the present series of tests, either a T-45 nose tire (19x5.25-10 12-ply) and wheel, or a T-45 main tire (24x7.7 20-ply) and wheel were mounted to the test fixture axle and low-speed tests were conducted by driving the ITTV over a dry, concrete taxiway. Vertical loads for the present testing ranged from 300 lb. to 900 lb. for the nose gear tire and 3000 lb. to 6000 lb. for the main gear tire. Yaw angles ranged from 0 to approximately +/- 20 degrees (See Appendix A for a listing of the test matrix). The ITTV responds to test tire side forces by acquiring a small opposing yaw angle until system side forces are

balanced. Prior to these tests, a series of tests was conducted to quantify this response resulting in an ITTV yaw angle correction of about one degree per 1000 lb. of side force at the test tire location. However, the yaw correction was utilized only for the main tire. The side loads developed by the nose tire were generally so small that the response of the ITTV in yaw was negligible. The investigation of the main tire also called for slip ratio tests. Slip tests were used to simulate wheel braking and to determine any reduction in cornering performance under mild to moderate braking. Slip ratios are defined as the difference between the ground speed and tire speed divided by the ground speed. For example, a locked, skidding tire would have a slip ratio of 1. The ITTV has a geared fixture that allows for different slip ratios to be selected. For these tests, the ratios varied from 0.04 to 0.11.

DATA ACQUISITION SYSTEM

During a test, the following parameters were measured:

- Yaw angle, deg (set mechanically with accuracy better than 0.1 deg)
- Vertical load, lb. (ch 5)
- Side Load #1, lb. (ch 6)
- Drag Load #2, lb. (ch 4)

Each of these analog measurements were converted to digital signals on-board the ITTV. The 12-bit system allows theoretical resolution of 1 count in 4096 counts. All channels (with corresponding parameters) have a linear behavior. Each side or drag channel is calibrated to independently give a measure of total side or drag. Side force and drag force interaction with vertical load is accounted for by using an offset "b" term and will most accurately reflect side loads at about 3000 lb. vertical load. Each channel was calibrated and the following sensitivities were recorded:

Ch 4 (Drag #2) "b"	231133 lb./volt (resolution of approx. 12 lb.)	-35.160 lb.
Ch 5 (Vertical)	328054 lb./volt (resolution of approx. 26 lb.)	0.000 lb. "b"
Ch 6 (Side #1) "b"	241626 lb./volt (resolution of approx. 12 lb.)	-4.7628 lb.

Positive side force is represented as a vector pointing towards the left side of the ITTV. Positive yaw angle is represented as a vector pointing towards the right side of the ITTV; thus a positive yawed-rolling test produced a negative side force. The yaw angle is defined as the angle between the wheel plane and the velocity vector, and the side and drag forces are measured perpendicular and parallel to the wheel plane. For each test

session the specimen was floated, in which the specimen was not touching the ground nor was the ITTV fixture "bottomed out" in the up direction. This also allowed for proper zeroes for each parameter to be recorded.

TEST AND MEASUREMENT TECHNIQUES / DATA ACCURACY

Footprints:

Deflection characteristics of each tire were defined using a technique of taking a "footprints" of the specimen at varying parameters. Different combinations of vertical load and tire pressure were tested. This series of tests was accomplished by placing a piece of white cardboard underneath the raised tire positioned on the ITTV's testing fixture and applying a thin layer of chalk to the tire's surface. The tire then left a chalk footprint on the cardboard when vertical load was applied by the test fixture. Care was taken so as not to apply a load greater than the reported load for each condition. These footprints illustrated the test tires' deflection and footprint area trends at each of the conditions of the actual ITTV rolling tests. Full-scale footprints for each tire under each of the load and pressure test conditions are presented in Appendix B.

General:

During this investigation, several types of tests were conducted. For each tire different variables, including tire pressure, vertical load, and yaw angle were held constant while one of the other variables was changed. Slip-ratio testing was conducted on the main tire only. The tests followed the planned test matrix (except for a few added repeat runs...see Appendix A) and each test run was saved as a different data file in the ITTV onboard computer for later analysis. During the testing, specific data files were periodically plotted on the onboard computer and were analyzed for general accuracy. Appendix A also includes plotted parameter time history data from each test.

Nose Tire Tests:

For these tests, the nose gear test tire was mounted on the ITTV test axle. The static load supported by each nose tire is approximately 6% of the aircraft weight. This should be distinguished from the true loads imposed on the nose tires during actual aircraft operations. The inflation pressure for the first set of tests was 125 psi. Test runs were made at this pressure with vertical loads ranging from 300 lb. to 900 lb. For these tests, the ITTV was driven down a small distance of the taxiway at low speeds while the onboard computer recorded data. After each run, the yaw angle of the tire was adjusted and the next run was initiated. This procedure continued down the length of the taxiway. New zeroes in the onboard computer were taken after vertical load changes were made. Yaw angles for these tests ranged from 0 to 20 degrees. A concern arose about the symmetry of the tire in the positive compared to the negative yaw direction. Therefore,

negative yaw angles were tested on the first series of runs at 600 lb. to test for symmetrical properties. The testing showed that the cornering was not symmetric with yaw angle, a common phenomenon typical of bias-ply tires and referred to as ply-steer. During the test runs at the other vertical loads, symmetry was tested as well. The same procedure as above was performed for the test runs at a tire pressure of 350 psi. Two tests were conducted to describe the sliding friction of the nose tire at a 90-degree yaw angle. These tests were designed to provide information on the moment that could be produced by the tire about the aircraft center of gravity in an extremely dynamic condition of high-yaw rates produced by a failed main gear tire.

Main Tire Tests:

The main gear tire tests were similar to those of the nose gear tire, with the exception of the addition of slip ratio tests. The tire inflation pressures remained at 125 psi and 350 psi. It was decided that vertical loads should range from 3000 lb. to 6000 lb. The static load supported by each main tire is approximately 44% of the aircraft's weight. This should be distinguished from the true loads imposed on the main tires during actual aircraft operations. Yaw angles for these tests ranged from 0 to 20 degrees (symmetry was evaluated by limited testing at negative yaw angles). A gearing system on the ITTV allows for an axle with a universal joint (driven by a chain connected to the ITTV rear tires) to be connected to the test tire axle. Different gears allow for different slip ratios. For the tests at hand, slip ratios were set at 3.7 % slip and 11.3 % slip. The yaw angles for the slip tests ranged from 0 to 10 degrees yaw. The full 20 degrees was not reached because of interference between the universal joint and other ITTV hardware.

Repeat Runs:

Repeat runs were made for each test tire (nose gear and main gear). The purpose of this was to evaluate the repeatability of the data acquired by the onboard electronic data system. These repeat runs were made at various vertical loads and at various yaw angles. Since the loads were very light on the nose gear tire and it was known that reading and loading accuracy are generally lower in this case, proportionally more repeat runs were required to confirm the repeatability. At the heavier vertical loads tested for the main gear tire, less repeat runs were needed

DATA ANALYSIS

All test data were acquired at a rate of 10 samples/sec. The onboard computer allowed the user to download the data from the test runs and print out a hard copy. Each data set contained separate time histories (usually for a duration of about ten seconds) of the measured parameters. From these time histories, an average for each parameter was determined by hand fairing a best-fit line through the data plot. Several seconds of test data were typically faired after the side forces had reached a steady-state condition due to variations in the vertical load data from rolling on the extremely stiff tires and slight runway surface height variations.

Error Analysis:

An error analysis was performed to investigate the effects of electronic system noise and plot reading accuracy of the data. Resolution for each channel was previously given. The system has relatively large errors associated with computing side force coefficients at low vertical loads. The vertical load was shown to have a reading accuracy of only about +/- 75 lb., due to several counts of system noise and also to the nature of rolling an extremely stiff tire on a real surface with real texture and bumps. The side force was shown to have about the same accuracy of about +/- 75 lb. Thus at 300 lb. vertical load and 10 degrees yaw, for example, the potential error in side force coefficient can be as high as +/- 0.3. This number reduces to +/- 0.17 and +/- 0.12 as the vertical load is increased to 600 lb. and 900 lb. respectively. At the high vertical load conditions for the main tire tests, similar analysis suggests that the potential error in side force coefficient is about +/- 0.04 and +/- 0.02 for the 3000 lb. and 6000 lb. vertical loads respectively.

Appendices A and C present plots for the one hundred and thirty test runs. The hand-read loads taken from the plots (generated using Labview software) were transferred to another plotting setup. These data for the nose and main gear tire tests were then plotted using Excel and Cricket Graph III. These plots are:

1. Side force coefficient vs. Yaw angle
2. Drag force coefficient vs. Yaw angle

The force coefficients were obtained by dividing the side or drag forces by the vertical loads, thus non-dimensionalizing the data. Comparison plots of the effects of various loads on the tire and the effects of different tire inflation pressures are included. These comparisons are plotted as side force coefficient or drag force coefficient versus yaw angle and are presented in Appendix C.

A third-order polynomial curve fit was generally applied to the data. The intention of using this type curve fit is the fact that as the yaw angle increases for the tire, there is generally seen a trend of increasing cornering efficiency as yaw angle increases up to a point, and then as yaw angle is increased further, the cornering efficiency begins

to drop. Thus, the curves tend to look fairly similar to lift coefficient versus angle of attack curves in aeronautics. For most of the tire cornering test conditions, both positive and negative yaw angles are plotted.

RESULTS AND DISCUSSION

The following discussion refers to the footprint figures presented in Appendix B and the data plots presented in Appendix C.

Tire Footprints:

Nose Tire:

Figures B1 through B6 present footprint areas for the nose gear tire for vertical loads ranging from 300 lb. to 900 lb. and for both 125 and 350 psi. inflation pressures. Comparing figure B1 with B4, one can see that a factor of almost 3 on inflation pressure does not cause the higher-pressure footprint to have one-third of the area of the lower-pressure footprint. In fact, there is only a very slight reduction in footprint area as the pressure is raised from 125 psi. to 350 psi. Comparisons of figures B2 and B5, or of figures B3 and B6 show other examples of the same phenomenon. These figures indicate that the tire vertical stiffness, at these loads, almost completely dominates the deflection behavior. Thus, the tire/ground contact pressure for each of these two inflation conditions is only modestly affected by the inflation pressure. This would lead one to believe that only a small reduction in cornering efficiency would be observed as the inflation pressure is increased from 125 psi. to 350 psi. Normally, the following empirical relationship can be used to describe an estimate for the maximum friction obtainable on dry concrete for a given inflation pressure:

μ max = 0.93-0.0011* P where P = inflation pressure in psi.

Since this tire is so stiff, this prediction technique is probably somewhat unreliable. These footprints demonstrate the extremely small contact patch for the nose tire under realistic operating loads. The footprints also show that at a given pressure, increasing the vertical load by a factor of 3 also does not increase the footprint area substantially; in fact the footprint area grows by only about 25 to 35% for the drastic change in load. Thus, the deflection range the tire is operated within, while numerically having loads that can change by a factor of three, is almost constant, suggesting that a single behavior in coefficient form is appropriate to describe its cornering behavior. This tire is operated substantially below the conditions it is designed to operate at, namely vertical loads of about 4000 lb., or in other words, a deflection of approximately 32%. In this highly unusual condition, while we have attempted to provide a model for the tire behavior, one should expect unusual behavior. Even before evaluating the tire cornering behavior, it is recommended that either the tire, the loads, or the pressure be changed so that the nose gear tires are operated at a more conventional deflection.

Main Tire:

Figures B7 through B10 present footprint areas for the main gear tire for vertical loads ranging from 3000 lb. to 6000 lb. and for both 125 and 350 psi. inflation pressures. Comparing figure B7 with B9, and comparing figure B8 with B10, one can see that a factor of almost 3 on inflation pressure does not cause the higher-pressure footprint to have one-third of the area of the lower-pressure footprint. In fact, the reduction in footprint area as the pressure is raised from 125 psi. to 350 psi. is only about 30 to 40%. These figures indicate that the tire vertical stiffness, at these loads, substantially dominates the deflection behavior. Thus, the tire/ground contact pressure for each of these two inflation conditions is only moderately affected by the inflation pressure. The footprints also show that at a given pressure, increasing the vertical load by a factor of 2 also does not increase the footprint area proportionately; in fact the footprint area grows by only about 50 to 60% for the drastic change in load. Thus, the deflection range the tire is operated within at a given pressure, while numerically having loads that can change by a factor of two, is almost constant, suggesting that a single behavior in coefficient form is appropriate to describe its cornering behavior, at least for a relatively large range in load. This tire is operated substantially below the conditions it is designed to operate at, namely vertical loads of about 12000 lb., or in other words, a deflection of approximately 32%. This tire is not operated in the extremely underloaded condition of the nose gear tire, but it is nevertheless operated well below its design deflection. Consideration should be given to changing the operating deflection of this tire as well.

Nose Tire Cornering:

Figure C1 shows a plot of side force coefficient (mu side) as a function of yaw angle at an inflation pressure of 125 psi. The plot shows three vertical loading conditions ranging from 300 lb. to 900 lb. Figure C2 shows a similar plot at an inflation pressure of 350 psi. A third order polynomial is curve-fit to each set of data but the equations for each are not presented. In most cases, the curve does not go through the origin. We believe there are two main reasons for this. First, the accuracy of the system is such that the precise measurements needed to actually determine the true intercept are nearly impossible. Included in this is the fact that the tire is so stiff that minute surface disparities can cause relatively high tire forces, showing up as "noise" in the tire vertical load measurement. A higher data acquisition rate would more clearly demonstrate this phenomena. Secondly, we believe that there is likely a phenomenon referred to as ply-steer occurring in which a bias-ply constructed tire can develop side forces at zero yaw angle due to the asymmetry, by definition, of the carcass of the tire. The asymmetry manifests itself as a twist in the footprint as the tire is deflected vertically. Also of note is the lack of a well-behaved trend in vertical load seen particularly in figure C1 where the normal expectation that side force coefficient reduces as vertical load increases is not present. The equations for the curves fit through these data are not presented because it was concluded that due to the extremely small deflection range actually observed, coupled with the inaccuracies of the measurement system at these low load levels, it is not possible to accurately predict the intricacies of the tire behavior at these conditions.

Rather, it makes better engineering sense to combine, at a minimum, all of the data generated at each inflation pressure and curve-fit a single line through all of the data. These plots are presented in figures C3 and C4. Thus, for a tire pressure of 125 psi on the nose tire, the following equation is suggested as the predictive tool for tire side force coefficient:

$$\mu \text{ side} = (6.869E\text{-}05)*Yaw^3 + (1.105E\text{-}04)*Yaw^2 - (6.846E\text{-}02)*Yaw + 5.103E\text{-}02$$

where Yaw = yaw angle in degrees

This model is valid for yaw angles between +/- 20 degrees and loads between 300 and 900 lbs.

For a tire pressure of 350 psi on the nose tire, the following equation is suggested as the predictive tool for tire side force coefficient:

$$\mu \text{ side} = (7.326E\text{-}05)*Yaw^3 + (2.549E\text{-}04)*Yaw^2 - (6.150E\text{-}02)*Yaw + 1.985E\text{-}01$$

where Yaw = yaw angle in degrees

This model is valid for yaw angles between +/- 20 degrees and loads between 300 and 900 lbs.

For both of the above models, for vertical loads less than 300 lbs. evaluate the side force as if the vertical load were 300 lbs. and then scale the result by the ratio of actual vertical load divided by 300. For vertical loads above 900 lbs. conduct a similar exercise in the other direction.

Due to the scatter in the data for the nose gear tire already discussed, it would likely be acceptable to condense all the test data at all loads and both pressures into one data set and fit a single curve to the data, although it was not decided to present the data in that way in this report. The apparent effect of pressure seemed to be slightly more significant than the apparent effect of load for the nose tire.

Figure C5 presents both curves and the data to which they were fit on the same plot. Figure C6 presents a plot of the repeat runs so that the repeatability of the testing can be seen. For each yaw angle plotted, there are two like data points which represent a set of repeated tests. The load for any specific set of tests is shown in the plot legend. As can be seen, in some cases the scatter for a set of repeat runs can be as high as 0.7, but an average scatter value is closer to about 0.2 to 0.4.

Two tests were conducted at a 90-degree yaw angle to simulate what might occur during a landing where one main gear tire is flat or dragging. The intent was to determine how much restoring torque is available at the nose gear in such a situation. The first test was conducted at 710 lbs. vertical load and the other at 240 lbs. The side force coefficients

were 0.42 and 0.66 respectively. The relevance of these numbers is seen in the following example. Suppose a landing with one main gear tire flat and the drag force coefficient on that gear is equal to 0.2. Due to the geometry of the vehicle, a lateral force of about 600 lbs. at the nose gear is necessary to prevent the vehicle from yawing in the direction of the failed tire. As can be seen in numerous videotapes of T-45 landings, often the nose gear load is extremely low as evidenced by an extended nose gear strut early in the rollout. This indicates the nose gear load may be in the 500-600 lb. load range. The 240 lb. vertical load test indicates that the force available at the nose gear may be only 320 lbs. This is only about half of the force required to restrain the vehicle from an uncommanded yaw in the direction of the failed tire. Thus, a low nose gear load combined with a failed main gear tire can produce a highly dynamic yaw condition that is uncommanded. In fact there may be a condition where there is not enough nose gear load to allow effective nose gear steering in which case the only other available means would be using the rudder pedals and differential braking. It is clear that a low nose gear vertical load is undesirable and can result in not only this highly dynamic situation but can also manifest itself as a classic under steer condition. Means to provide increased nose gear load on this vehicle should be examined.

Main Tire Cornering:

Figure C7 shows a plot of side force coefficient (mu side) as a function of yaw angle for a vertical load of 3000 lbs. and for inflation pressures of both 125 psi. and 350 psi. Figure C8 shows a similar plot at 6000 lbs. vertical load. A third order polynomial is curve-fit to each set of data. Due to the nature of the higher loads imposed on these tires during testing, less data scatter is seen and a more well-behaved set of data results. As a result of the behavior of the footprints for the main gear tire seen in Appendix B, it was determined that the deflection of the tire was relatively constant at either the 125 psi. or 350 psi. inflation pressure. Thus the data was divided into two sets, one at 3000 lbs. and the other at 6000 lbs. So, for a vertical load of 3000 lbs. and either tire pressure on the main tire, the following equation is suggested as the predictive tool for tire side force coefficient:

$$\mu \text{ side} = (1.083E\text{-}04)*Yaw^3 - (8.781E\text{-}05)*Yaw^2 - (6.923E\text{-}02)*Yaw + 3.313E\text{-}02$$

where Yaw = yaw angle in degrees

This model is valid for yaw angles between +/- 20 degrees.

For a vertical load of 6000 lbs. and either tire pressure on the main tire, the following equation is suggested as the predictive tool for tire side force coefficient:

$$\mu \text{ side} = (6.970E\text{-}05)*Yaw^3 - (3.986E\text{-}05)*Yaw^2 - (5.336E\text{-}02)*Yaw + 2.461E\text{-}02$$

where Yaw = yaw angle in degrees

This model is valid for yaw angles between +/- 20 degrees.

For vertical loads between 3000 lbs. and 6000 lbs., evaluate both models at the proper yaw angle and derive the side forces. Then interpolate between the side force values to calculate the side force based on the interim load. For loads below 3000 lbs., evaluate the 3000 lb. model at the proper yaw angle and then scale the resultant side force by the ratio of actual vertical load divided by 3000. For vertical loads above 6000 lbs. conduct a similar exercise in the other direction.

Comparing figures C7 and C8, one can see a reduction in the cornering power, or slope, of the mu vs. yaw curve for the 6000 lb. data. This is a typical phenomenon where increases in load, or deflection, tend to reduce the cornering efficiency of a tire after a certain point.

Figure C9 presents a plot of the repeat runs so that the repeatability of the testing of the main gear tire can be seen. For each yaw angle plotted, there are two like data points which represent a set of repeated tests. The load for any specific set of tests is shown in the plot legend. The data show very good repeatability and significantly less scatter than the data for the nose gear tire, and thus provides a strong basis for confidence in the models for the main gear tires.

Main Tire Braking:

Several tests using fixed slip ratio were conducted to determine the effects of braking on the drag coefficient of the main tire as well as any reduction in cornering capability in the presence of braking. Two fixed slip ratios were selected to represent mild and moderate braking; 3.7 percent and 11.3 percent respectively (again, a locked wheels skid would represent 100 percent slip). These tests were conducted under a nominal 3000 lb. vertical load and at a tire pressure of 125 psi. to most closely represent the runway environment under which braking would occur. Figure C10 presents a plot of drag coefficient vs. yaw angle for both the zero slip condition and the other two slip ratios. The drag coefficient is defined as the drag load in the plane of the wheel divided by the vertical load. As can be seen in figure C10, increasing the slip ratio increases the drag coefficient and for any given slip ratio, increasing the yaw angle tends to decrease the amount of drag capability of the tire. Figure C11 presents a plot of side force coefficient vs. yaw angle for 0, 3.7, and 11.3 percent slip ratios. The plot shows that for a given yaw angle increasing the slip ratio of tire, or braking, tends to reduce the amount of side force coefficient generated. This is a common phenomenon and occurs because there is only a certain amount of friction available in the footprint, so there exists a trade-off between the amount of cornering and braking force that can occur at any one time. A simple model to describe this reduction in side force coefficient as slip ratio is increased is as follows:

$$\mu \text{ side}_{slip} = \mu \text{ side}_{free} * (1-0.0545*SLIP)$$

where SLIP = the braking slip ratio in percent (for these tests the values would be described as 3.7 or 11.3)

and μ side $_{free}$ = the value of side force coefficient as calculated previously without slip

This model is valid out to yaw angles of approximately 10 degrees. This simple model assumes a linear relationship for the effect of slip ratio on side force coefficient and neglects any effect of increasing yaw angle itself. A more complex model including yaw angle could be generated but for most simulation purposes the simple form of the model is most likely sufficient.

CONCLUSIONS

A series of tests was conducted to define the cornering behavior of both the main and nose gear tires of the T-45 aircraft. Additional tests were conducted to determine the braking behavior of the main gear tire as well as any reduction in side force coefficient under the presence of braking. The load, yaw angle, and tire pressures in this investigation were selected to encompass as much of the T- 45 aircraft operational envelope as possible. From this investigation the following conclusions were reached:

1. Both the main and nose gear tires are extremely stiff, resulting in an extremely small contact area regardless of the tire pressure or load.
2. Both the main and nose gear tires are operated in an extremely under-loaded condition, especially the nose gear tire, and especially when inflated to 350 psi.
3. The main and nose gear tires have reasonably similar cornering capability. However, if the nose gear is operated at less than its proper load (meaning its normal static load based on the position of the aircraft CG) an under-steer condition will exist wherein the main gear tires produce more than their share of yaw moment during cornering as compared to the nose gear tires. Thus, with less than the normal static load on the nose gear the vehicle would be prone to pilot induced oscillations in the yaw direction.
4. Due to the stiffness of the nose gear tires, very little deflection difference exists between 300 lbs. and 900 lbs. vertical load. Since variations in cornering behavior (side force coefficient) are typically caused by deflection, it is acceptable to model the side force coefficient with a single behavior curve within this load range at a given pressure. The difference in tire deflection due to inflation pressure is observable, albeit small. Thus a separate curve to describe the cornering behavior at the higher inflation pressure is given.
5. The stiffness of the nose gear tires, at either pressure, combined with the relatively low average load on the tires also causes relatively large variations in normal load while traversing any surface due to very small disparities of the surface. This tends to contribute to a rather large range of data scatter during testing of this tire and also negatively influences repeatability of testing.
6. Main gear tire testing indicated that at a given load, a single curve is sufficient to describe the cornering behavior of the tire at either inflation pressure. For the main gear tire, doubling the vertical load had the typical effect of reducing the cornering efficiency and thus a separate curve is presented for each load tested.
7. Exceptional repeatability was demonstrated during main gear tire testing.

8. Fixed slip ratio testing defined the effect of slip ratio on drag coefficient. As slip ratio increases, corresponding decreases in cornering efficiency, or side force coefficient, are observed.

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Appendix A

T-45 Nose and Main Gear Tire Test Matrix

T-45 Nose and Main Gear Tire Data Plots

T-45 Nose and Main Tire Cornering Test Matrix

Revision B **Actual Test Matrix Followed as of 9/15/98**

Notes: Two weight conditions....approx. zero-fuel=10700 lb
and approx. max=14500lb

Static loads: Main tires=approx. 44% weight/tire
Nose tires=approx. 6% weight/tire
(+yaw=steer right=negative side load)

Note: **R = repeat**
N = negative yaw
B = backward

Nose Tire:

Run	Pressure, psi	Nom. load, lb	Yaw angle	Vertical load, lb	Side load, lb	Side coeff.	Comments:
run1	125	600	0	625	-10	-0.016	Run 1-17 define directional symmetry
run2	125	600	2	590	-175	-0.29661	changed lload for symmetry work
run3	125	600	4	570	-240	-0.421053	to 600 lb.. perhaps a little more
run4	125	600	6	600	-375	-0.625	realistic load look at symmetry
run5	125	600	8	620	-400	-0.645161	
run6	125	600	10	600	-470	-0.783333	
run7	125	600	12	630	-450	-0.714286	
run8	125	600	15	660	-550	-0.833333	
run9	125	600	20	700	-640	-0.914286	
run10	125	600	-2	650	140	0.2153846	
run11	125	600	-4	680	200	0.2941176	
run12	125	600	-6	650	260	0.4	
run13	125	600	-8	675	350	0.5185185	
run14	125	600	-10	630	400	0.6349206	
run15	125	600	-12	620	450	0.7258065	
run16	125	600	-15	625	500	0.8	
run17	125	600	-20	600	520	0.8666667	
run18	125	300	0	340	80	0.2352941	this series switched to 300lb
run19	125	300	2	320	0	0	
run20	125	300	4	250	-50	-0.2	
run21	125	300	6	375	-80	-0.213333	
run22	125	300	8	350	-90	-0.257143	
run23	125	300	10	390	-150	-0.384615	
run24	125	300	12	390	-210	-0.538462	
run25	125	300	15	380	-240	-0.631579	
run26	125	300	20	325	-190	-0.584615	
run27	125	900	0	960	130	0.1354167	Seemed to be ply steer....rezeroed and
run27R	125	900	0	900	0	0	repeated...ply steer present
run27RB	125	900	0	910	-80	-0.087912	
run28	125	900	2	980	0	0	Ply steer away from inflation valve
run29	125	900	4	950	-230	-0.242105	and away from tire S/N
run29N	125	900	-4	950	500	0.5263158	Run 27RB, rolling backward to confirm
run30	125	900	6	950	-310	-0.326316	ply steer
run31	125	900	8	1000	-400	-0.4	
run31N	125	900	-8	1000	740	0.74	Repeat 31 but at neg. yaw
run32	125	900	10	1000	-500	-0.5	
run33	125	900	12	1000	-575	-0.575	

Appendix A
T-45 Test Matrix Rev B

run33N	125	900	-12	950	800	0.8421053	Repeat 33 but at neg. yaw			
run34	125	900	15	950	-625	-0.657895				
run34N	125	900	-15		missing		Repeat 34 but at neg. yaw			
run35	125	900	20	1000	-700	-0.7				
run35N	125	900	-20	1000	1000	1	Repeat 35 but at neg. yaw			
run36	350	300	0		blank					
run36R	350	300	0	250	-30	-0.12	Side forces low..prob. a lot of scatter			
run37	350	300	2	325	20	0.0615385				
run38	350	300	4	310	0	0				
run38R	350	300	4	350	-200	-0.571429				
run38N	350	300	-4	300	225	0.75	Repeat 38 but at neg. yaw			
run38NR	350	300	-4	360	100	0.2777778	Repeat 38N			
run39	350	300	6	300	-10	-0.033333				
run40	350	300	8	250	0	0				
run40R	350	300	8	300	-210	-0.7	Repeat 40 but at neg. yaw			
run40N	350	300	-8	310	250	0.8064516	Repeat 40N			
run40NR	350	300	-8	300	200	0.6666667				
run41	350	300	10	300	-25	-0.083333				
run42	350	300	12	300	-90	-0.3				
run42R	350	300	12	375	-250	-0.666667				
run42N	350	300	-12	300	250	0.8333333	Repeat 42 but a neg. yaw			
run42NR	350	300	-12	340	200	0.5882353	Repeat 42N			
run43	350	300	15	300	-50	-0.166667				
run44	350	300	20	275	-50	-0.181818	Note: 350psi and 600lb removed..			
run45	350	900	0		blank		see if 125psi interpolation works			
run46	350	900	2	900	0	0	first then decide on 600lb			
run47	350	900	4	890	-160	-0.179775				
run48	350	900	6	900	-225	-0.25				
run49	350	900	8	900	-300	-0.333333				
run50	350	900	10	880	-375	-0.426136				
run51	350	900	12	860	-410	-0.476744				
run52	350	900	15	880	-500	-0.568182				
run53	350	900	20	890	-500	-0.561798				
run54	350	300	2	275	10	0.0363636	Repeat run 37			
run55	350	900	8	900	-275	-0.305556	Repeat run 49			
run56	350	600	90	710	-300	-0.422535	Static yaw moment test			
run57	350	300	90	240	-160	-0.666667	Unstroked nose gear test			
run58	125	600	4	600	-215	-0.358333	Repeat run 3			
run59	125	300	12	325	-250	-0.769231	Repeat run 24			
run60	125	600	-2	620	200	0.3225806	Repeat run 10			
run61	125	600	-15	600	510	0.85	Repeat run 16			
run201	350	600	0	600	80	0.1333333	Add some runs at 350psi, 600lb			
run202	350	600	4	600	-90	-0.15	w/pos and neg yaw to round out tests			
run202N	350	600	-4	600	250	0.4166667				
run203	350	600	8	600	-200	-0.333333				
run203N	350	600	-8	600	300	0.5				
run204	350	600	12	600	-250	-0.416667				
run204N	350	600	-12	600	490	0.8166667				

Appendix A
T-45 Test Matrix Rev B

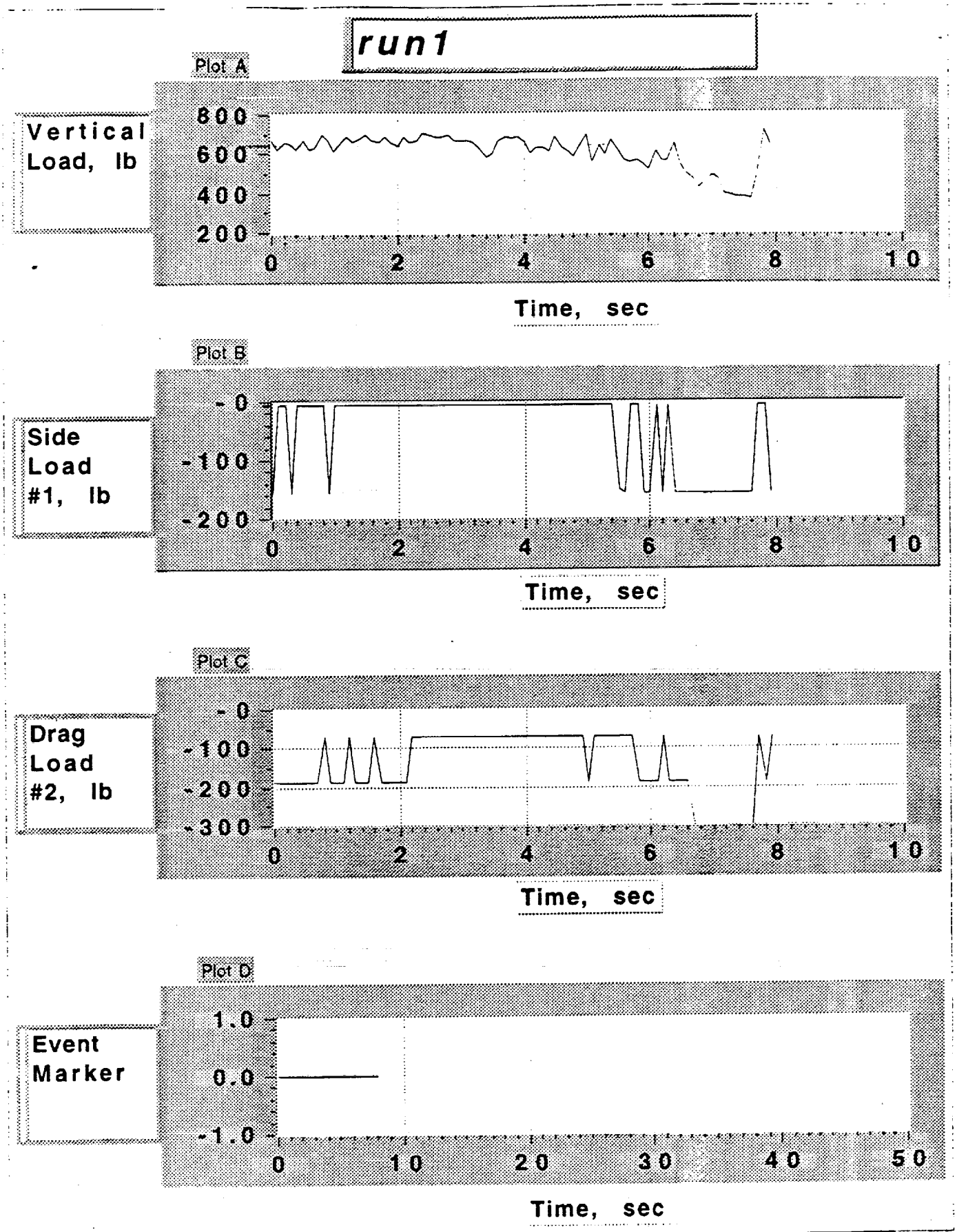
Main Tire:

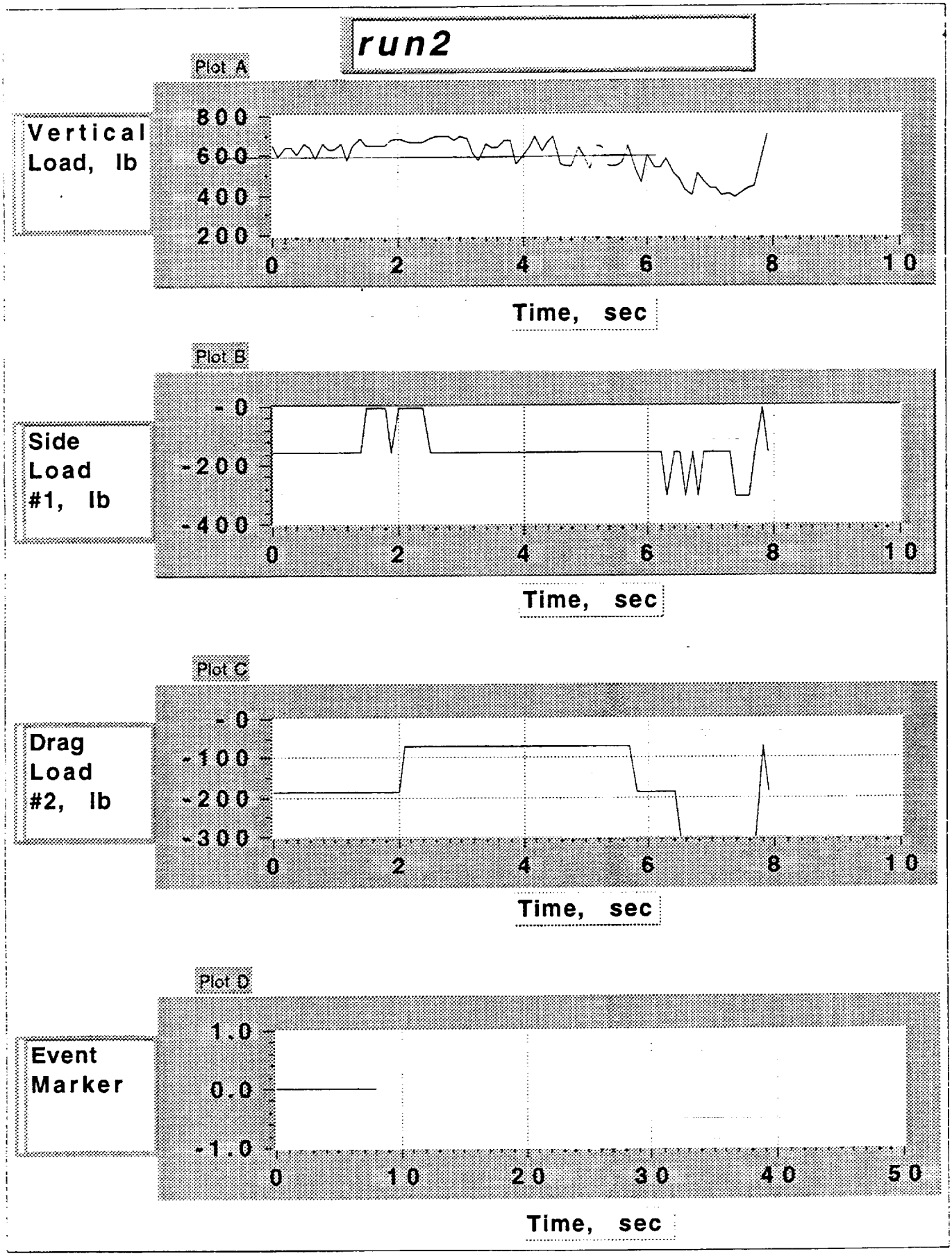
Run	Pressure, psi	Nom. load, lb	Yaw angle	Vertical load, lb	Side load, lb	Corrected yaw angle	Drag load lb	Comments:
run62	125	3000	0	3100	75	0	45	Runs 62-78 define
run63	125	3000	2	3090	-425	1.575	50	symmetry
run64	125	3000	4	2990	-800	3.2	45	
run65	125	3000	6	2975	-1200	4.8	95	
run66	125	3000	8	3000	-1500	6.5	110	
run67	125	3000	10	2975	-1550	8.45	110	changed load for symmetry
run68	125	3000	12	2900	-1800	10.2		work to 3000lb..
run69	125	3000	15	2900	-2010	12.99		perhaps a more realistic
run70	125	3000	20	2900	-2100	17.9		load to look at symmetry
run71	125	3000	-2	3100	500	-1.5		
run72	125	3000	-4	3190	1000	-3		
run73	125	3000	-6	3150	1300	-4.7		
run74	125	3000	-8	3210	1600	-6.4		
run75	125	3000	-10	3250	1750	-8.25		
run76	125	3000	-12	3110	1800	-10.2		
run77	125	3000	-15	3140	2000	-13		
run78	125	3000	-20	3170	2000	-18		Data appears reasonably
run79	125	6000	0	6300	240	0.24		symmetric
run80	125	6000	2	6300	-300	1.7		
run81	125	6000	4	6250	-800	3.2		
run81N	125	6000	-4	6240	1100	-2.9		Repeat 81 but at neg. yaw
run82	125	6000	6	6200	-1200	4.8		
run83	125	6000	8	6200	-1700	6.3		
run83N	125	6000	-8	6190	2000	-6		Repeat 83 but at neg. yaw
run84	125	6000	10	6050	-2100	7.9		
run85	125	6000	12	6100	-2600	9.4		
run85N	125	6000	-12	6120	2800	-9.2		Repeat 85 but at neg. yaw
run86	125	6000	15	5950	-3000	12		
run86N	125	6000	-15	6000	3200	-11.8		Repeat 86 but at neg. yaw
run87	125	6000	20	5950	-3400	16.6		
run88	350	3000	0	3040	140	0.14	15	
run89	350	3000	2	2975	-275	1.725	40	
run90	350	3000	4	2975	-650	3.35	60	
run91	350	3000	6	2900	-800	5.2	95	
run91N	350	3000	-6	3100	1200	-4.8	-25	
run92	350	3000	8	2950	-1050	6.95	85	
run93	350	3000	10	2910	-1200	8.8	100	
run94	350	3000	12	2875	-1400	10.6	100	
run94N	350	3000	-12	3100	1750	-10.25	-40	
run95	350	3000	15	2900	-1500	13.5	120	
run96	350	3000	20	2850	-1550	18.45	130	

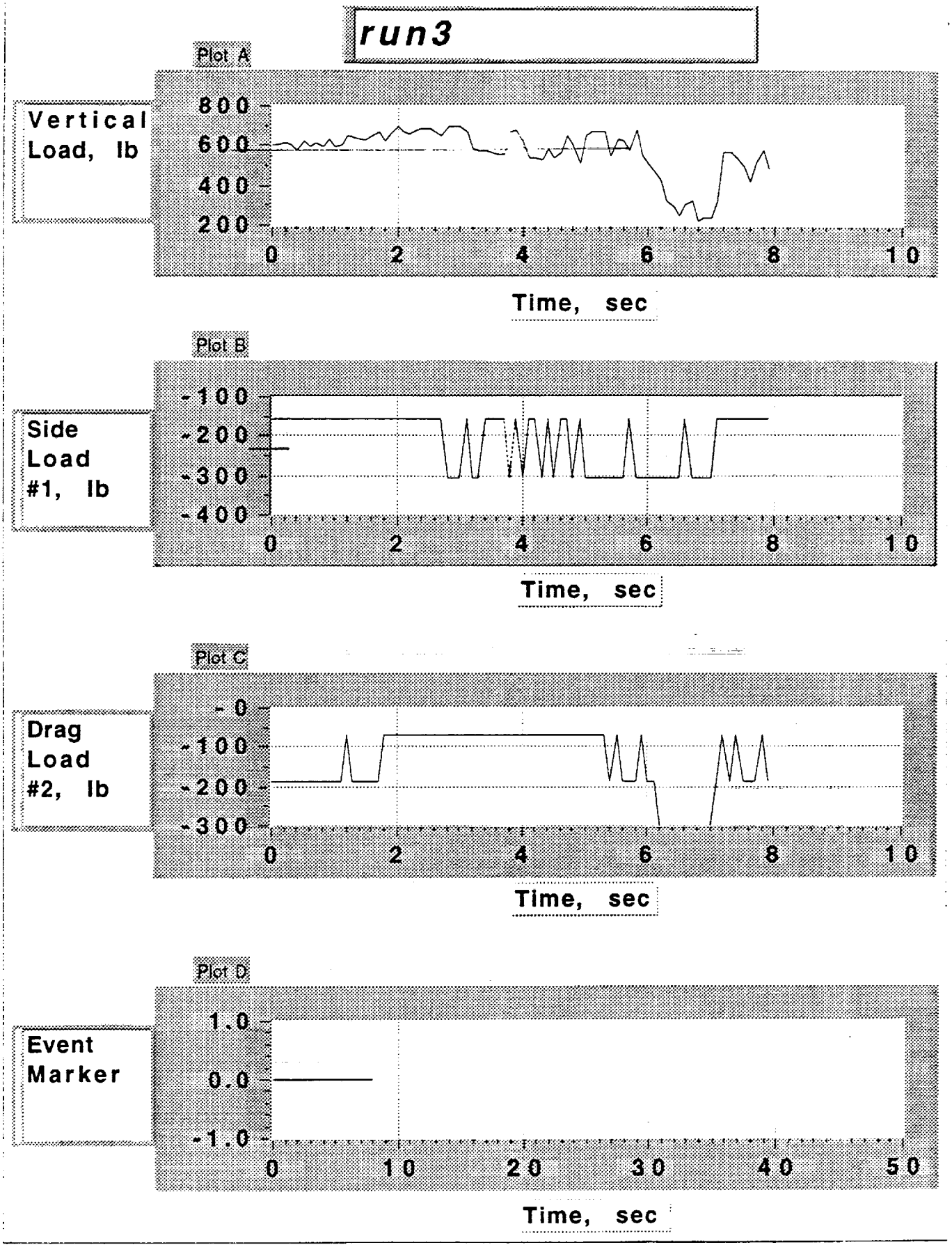
Appendix A
T-45 Test Matrix Rev B

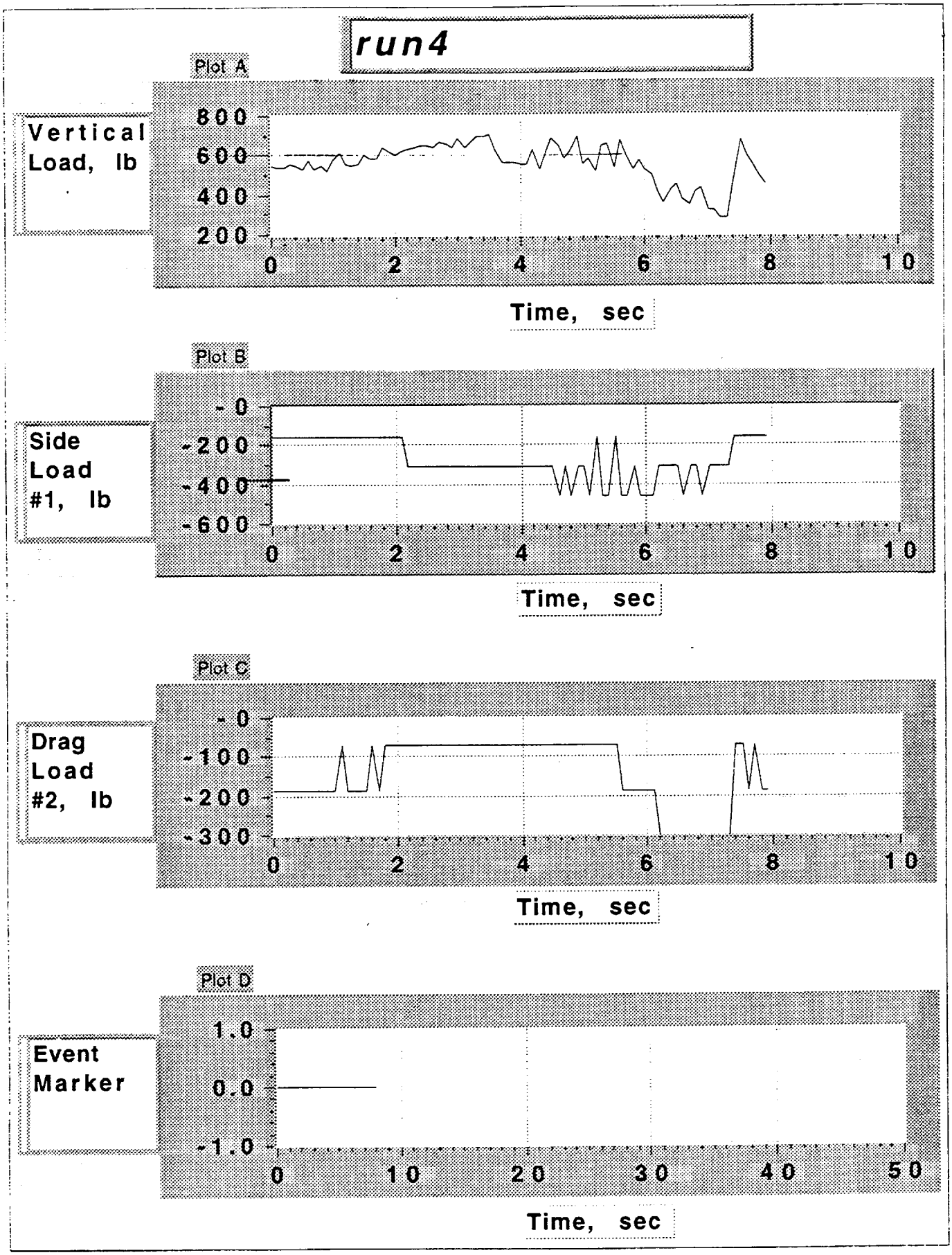
run96N	350	3000	-20	3200	2025	-17.975	-10			
run97	350	6000	0	6250	175	0.175	95			
run98	350	6000	2	6125	-300	1.7	110			
run99	350	6000	4	6000	-1000	3	140			
run100	350	6000	6	6000	-1090	4.91	160			
run100N	350	6000	-6	6200	1190	-4.81	50			
run101	350	6000	8	5990	-2000	6	155			
run102	350	6000	10	5950	-2250	7.75	160			
run103	350	6000	12	5900	-2750	9.25	185			
run103N	350	6000	-12	6000	2900	-9.1	35			
run104	350	6000	15	5900	-3000	12	200			
run105	350	6000	20	5800	-3010	16.99	220			
run105N	350	6000	-20	6000	3500	-16.5	10			
run106	125	3000	0	3160	-50	-0.05	850	ITTV Gear 4 (Slip ratio= 0.037)		
run107	125	3000	2	3050	-250	1.75	700	Tire skidded 4 feet at end		
run108	125	3000	4	3000	-600	3.4	700	of test (100% slip)		
run109	125	3000	6	3000	-1050	4.95	600			
run110	125	3000	8	2880	-1400	6.6	550			
run111	125	3000	10	2975	-1550	8.45	300			
run112	125	3000	12	Did not run...interference with u joint						
run113	125	3000	15	Did not run...interference with u joint						
run114	125	3000	20	Did not run...interference with u joint						
run115	125	3000	0	3200	-200	-0.2	1725	ITTV Gear 7 (Slip ratio= 0.113)		
run116	125	3000	2	3190	-100	1.9	1450			
run117	125	3000	4	3100	-250	3.75	1300			
run118	125	3000	6	3075	-450	5.55	1250			
run119	125	3000	8	3050	-800	7.2	1100			
run120	125	3000	10	3045	-1000	9	1100			
run121	125	3000	12	Did not run...interference with u joint						
run122	125	3000	15	Did not run...interference with u joint						
run123	125	3000	20	Did not run...interference with u joint						
run124	350	3000	2	2990	-250	1.75	25	Repeat run 89		
run125	350	3000	8	2900	-1150	6.85	60	Repeat run 92		
run126	125	3000	-6	3000	1350	-4.65	-20	Repeat run 73		
run127	125	3000	12	2900	-1750	10.25	125	Repeat run 68		
run128	125	6000	4	6000	-700	3.3	85	Repeat run 81		
run129	350	6000	6	6000	-1100	4.9	120	Repeat run 100		

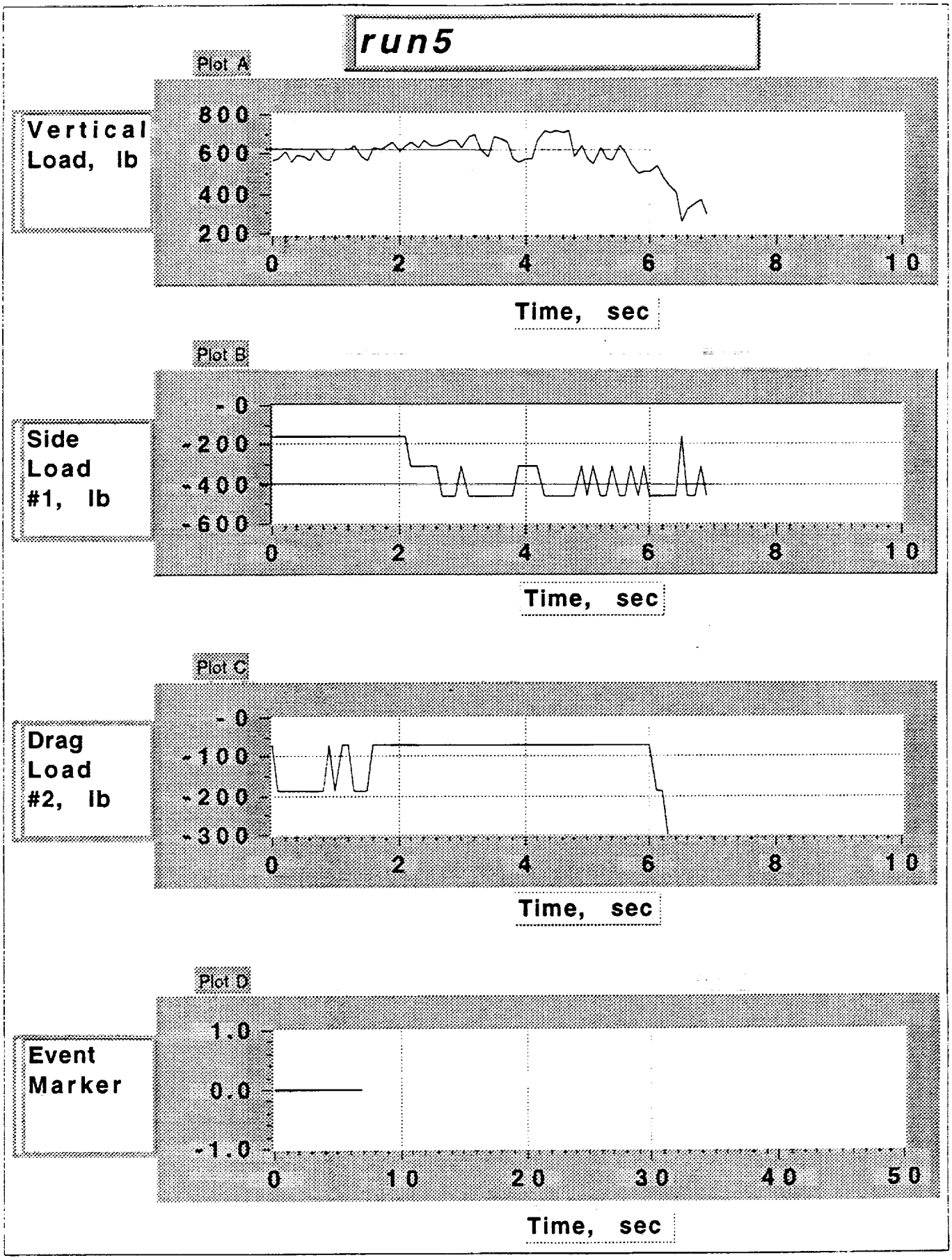
T-45 Nose Gear Tire Test Run Parameter Time Histories

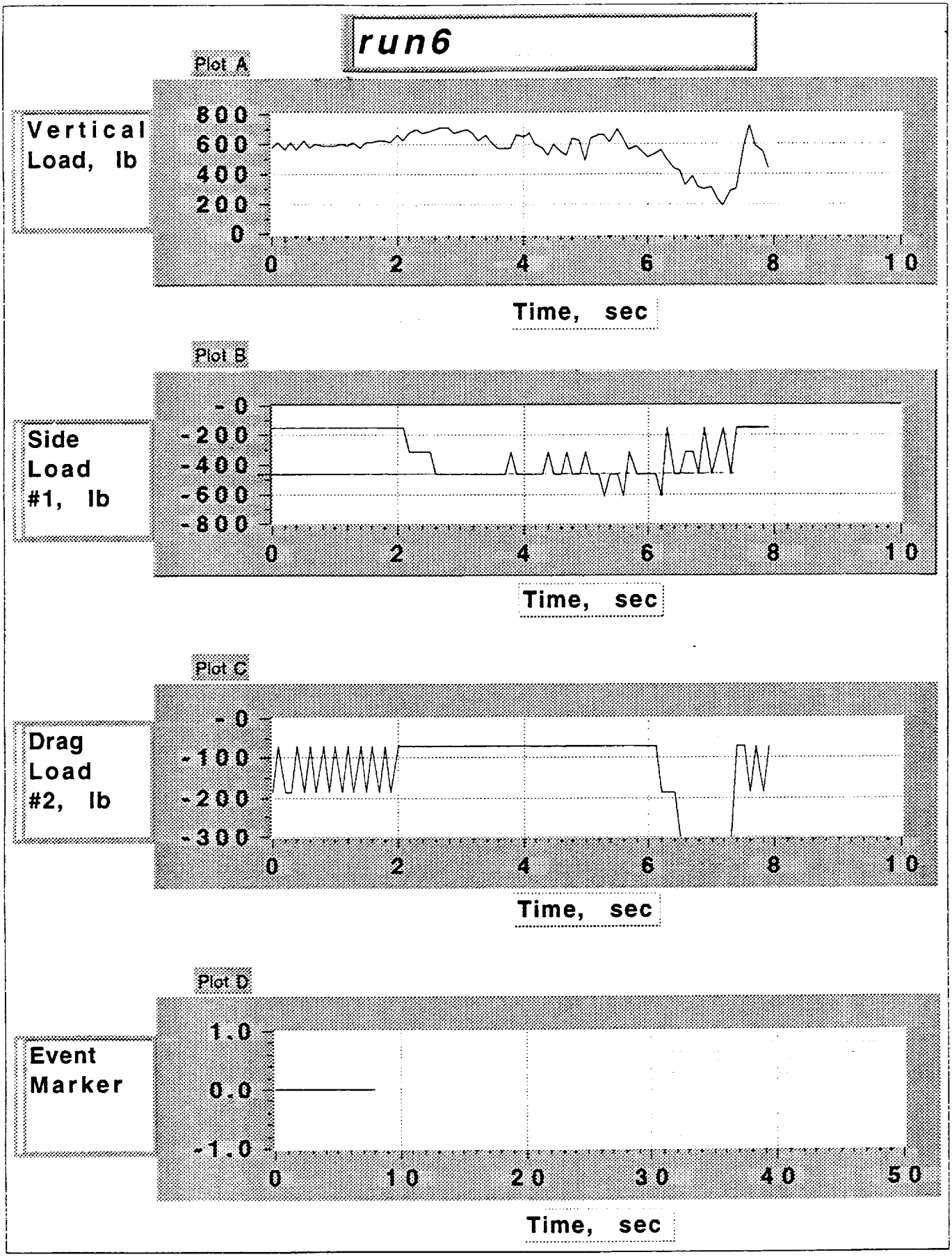

run1
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-100
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

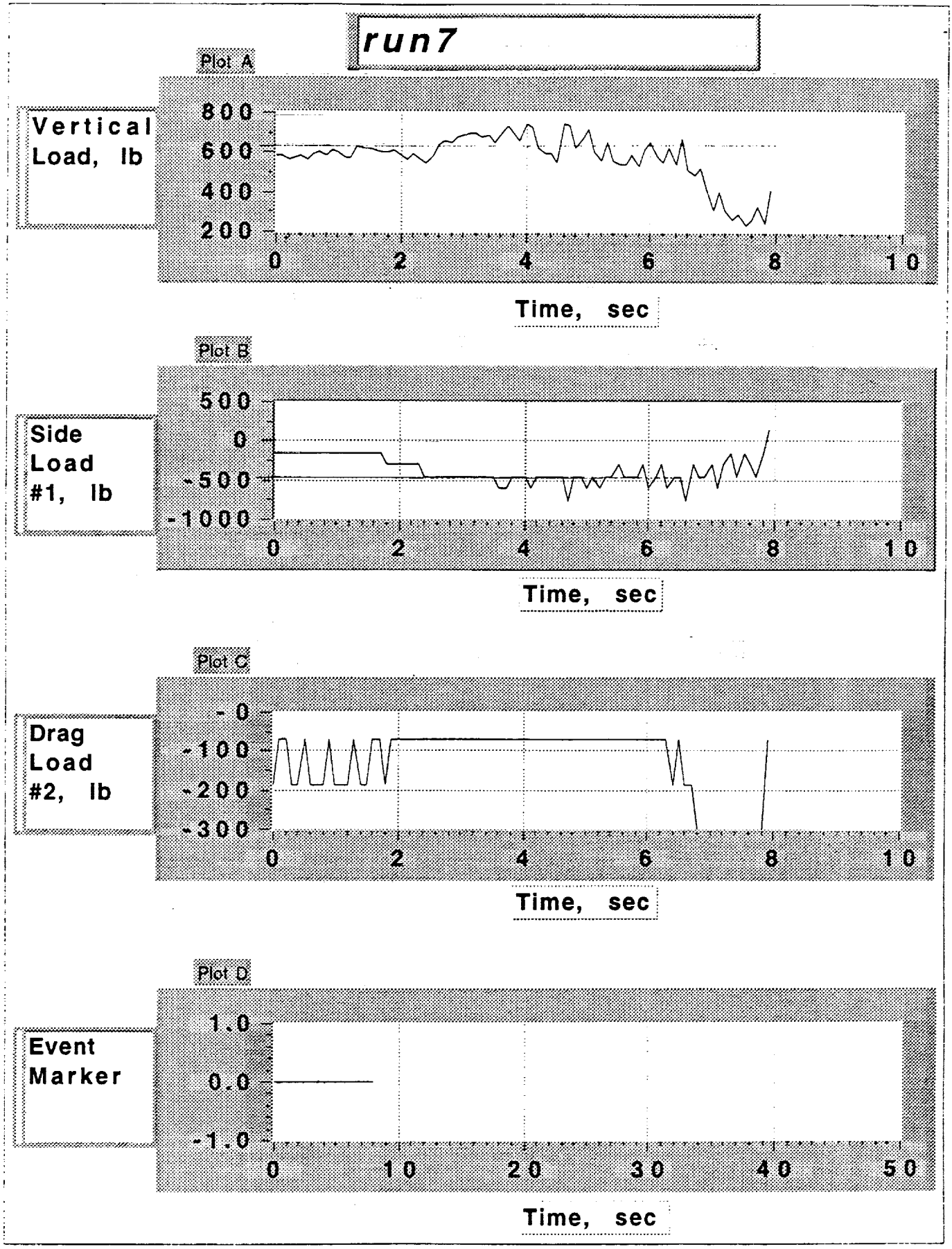

run2
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

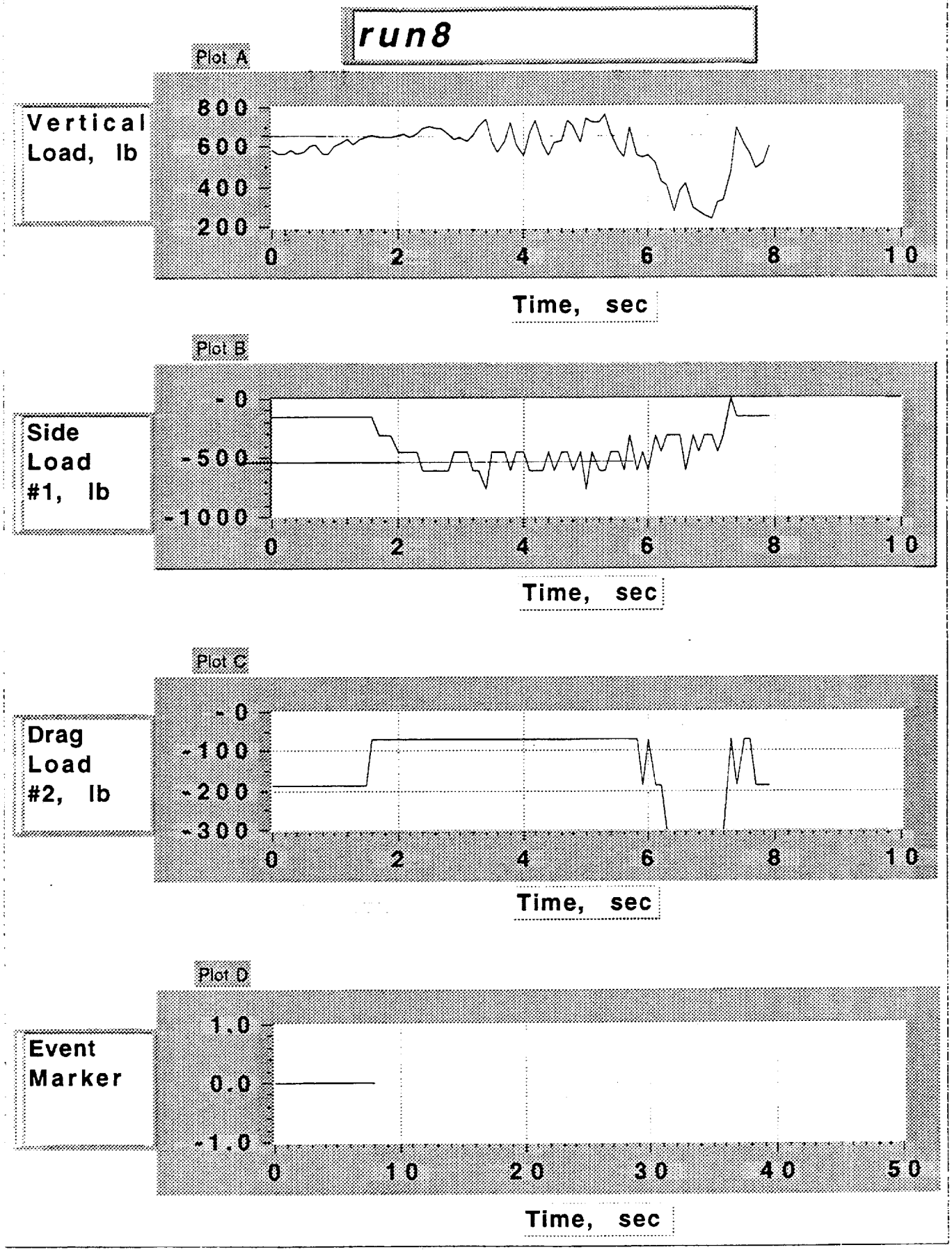

run3
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-100
-200
-300
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
- 0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

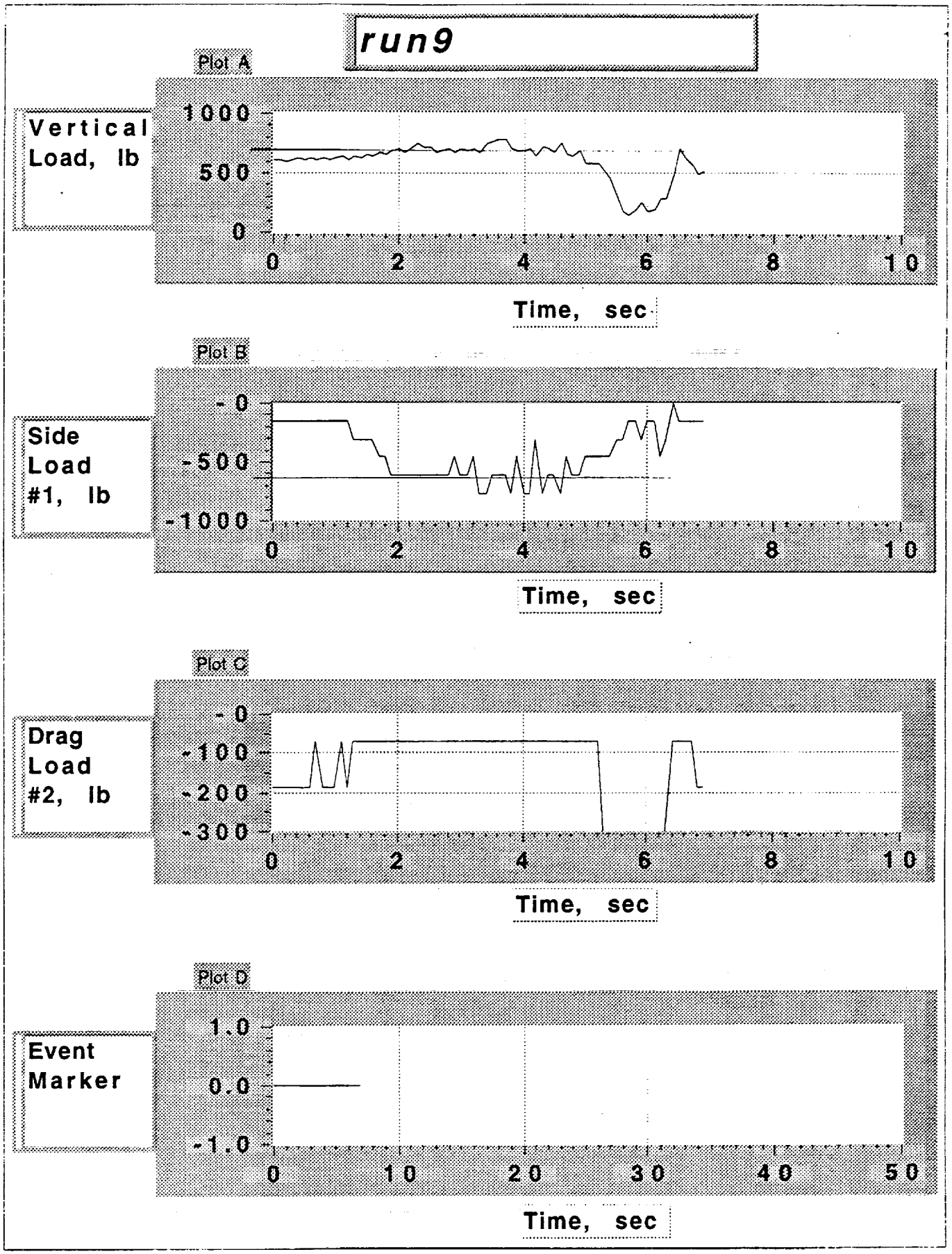

run4
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
-600
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

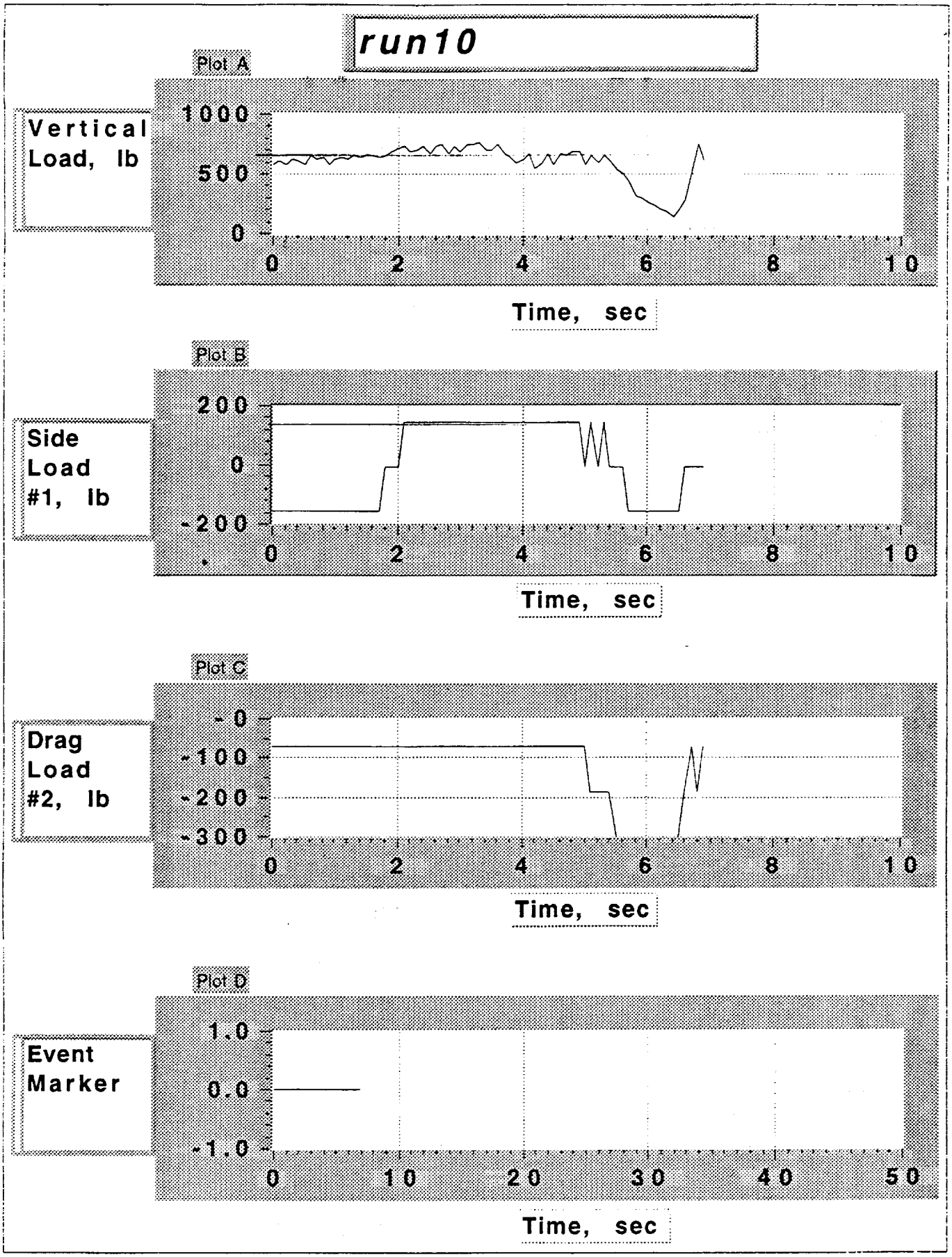

run5
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
- 0
-200
-400
-600
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
- 0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

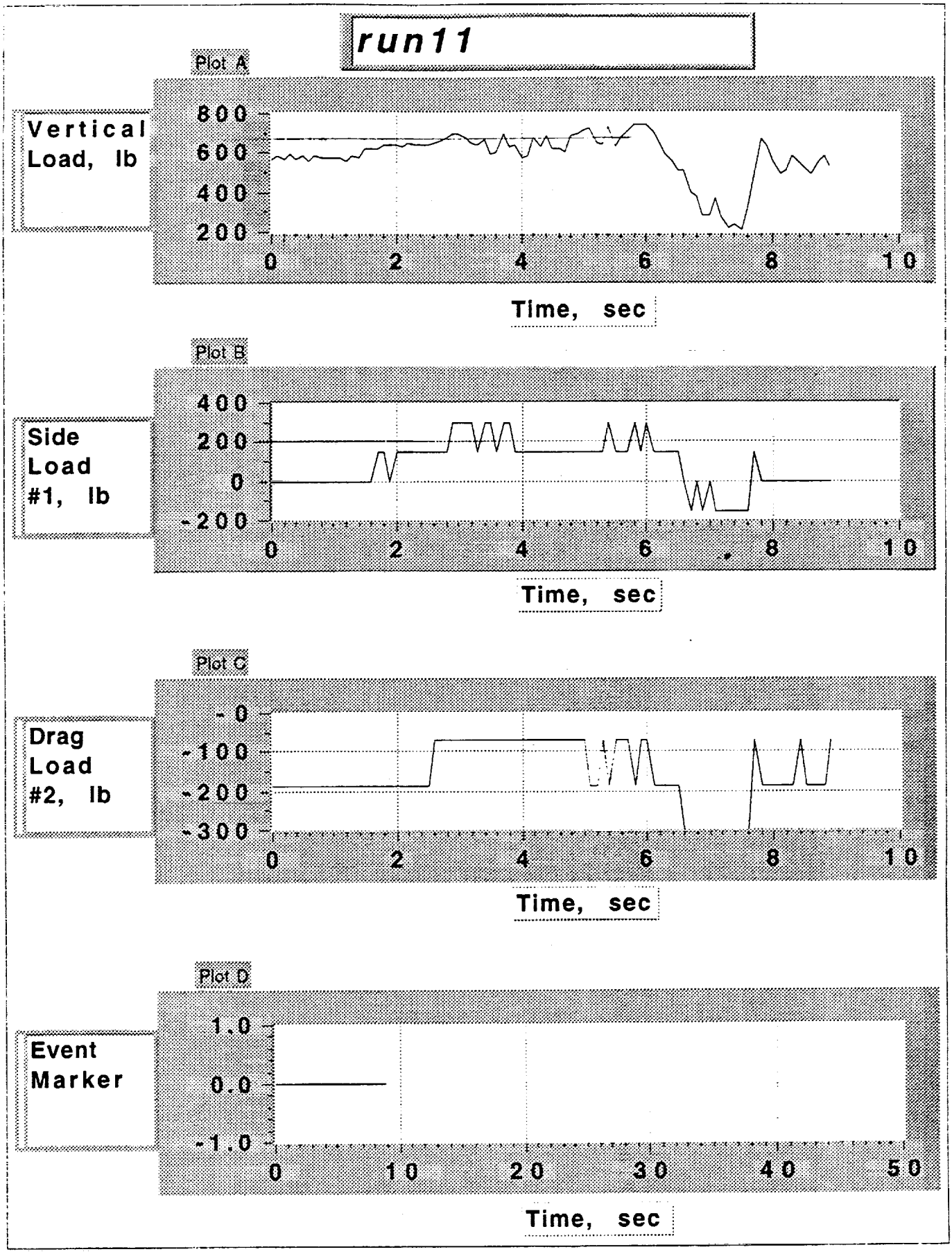

run6
Plot A
Vertical Load, lb
800
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
-600
-800
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

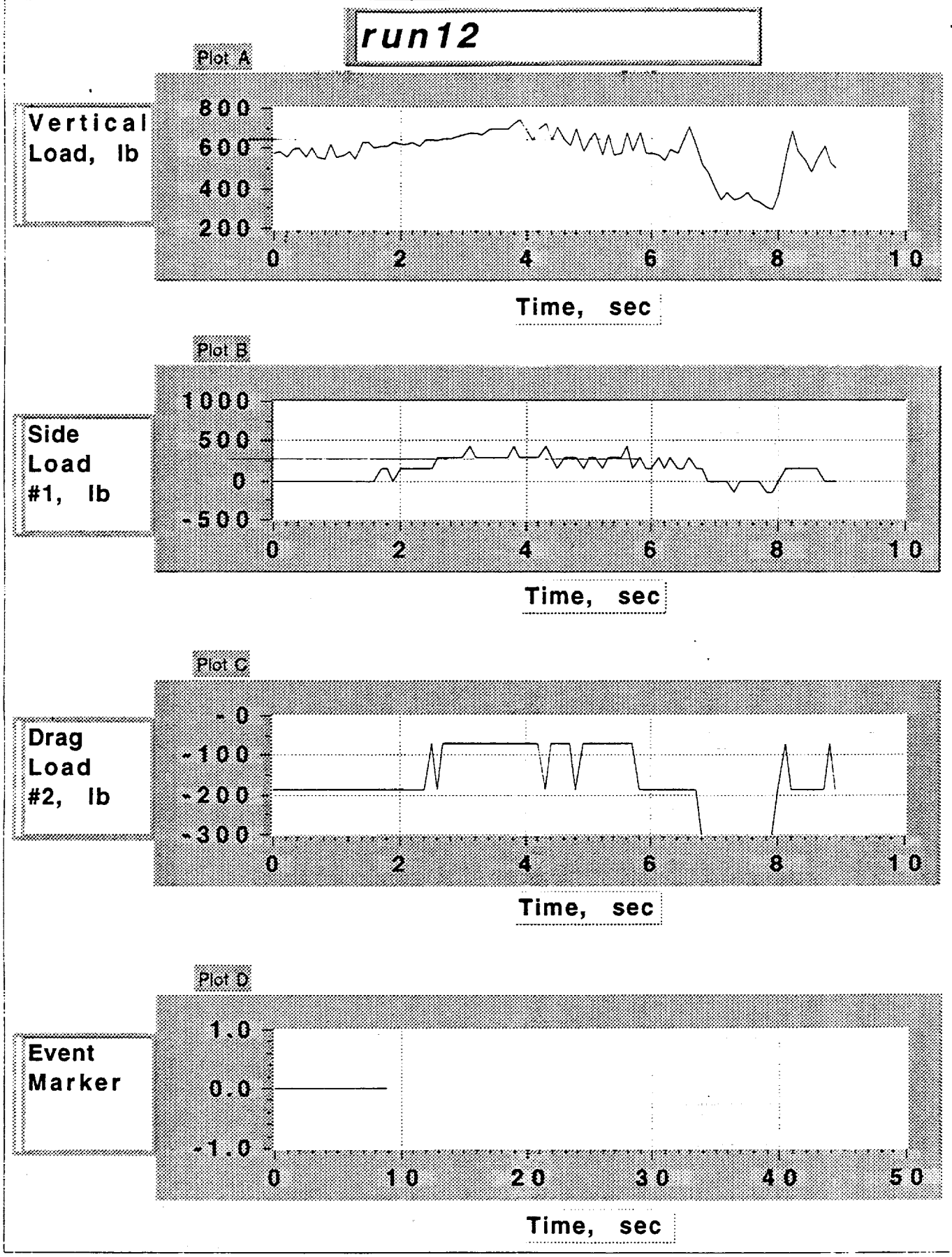

run7
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

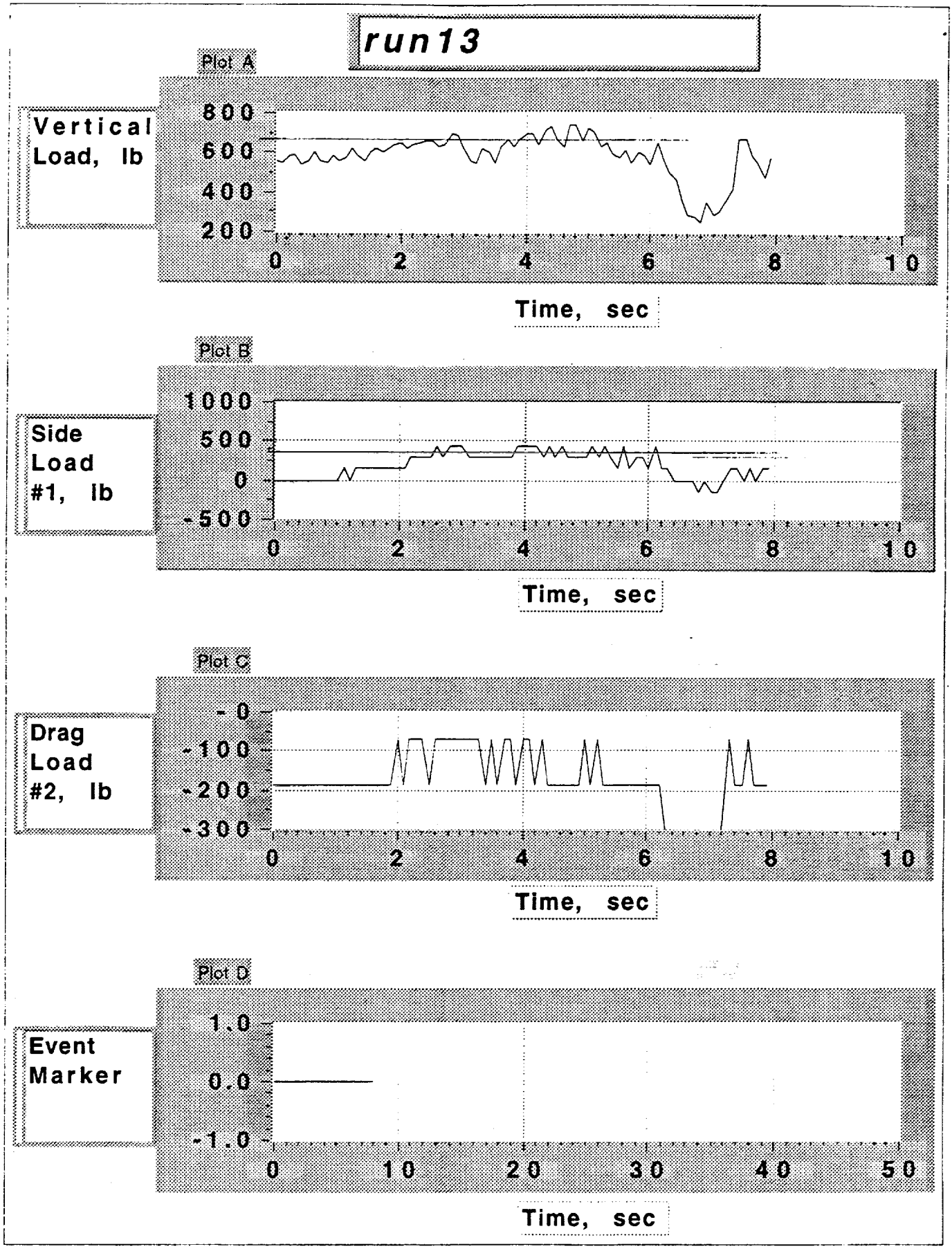

run8
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
- 0
- 500
- 1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
- 0
- 100
- 200
- 300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
- 1.0
0
10
20
30
40
50
Time, sec

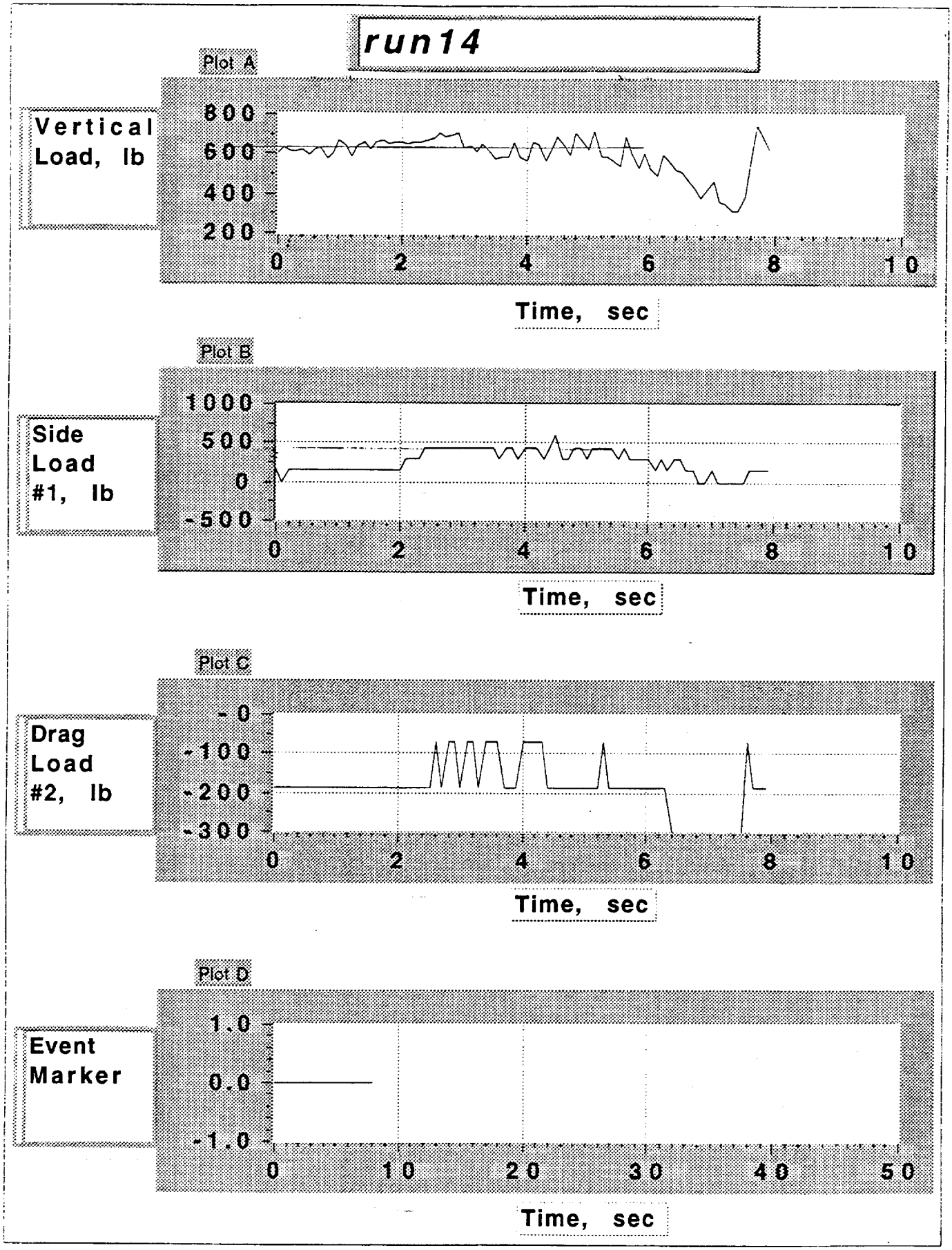

run9
Plot A
Vertical Load, lb
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

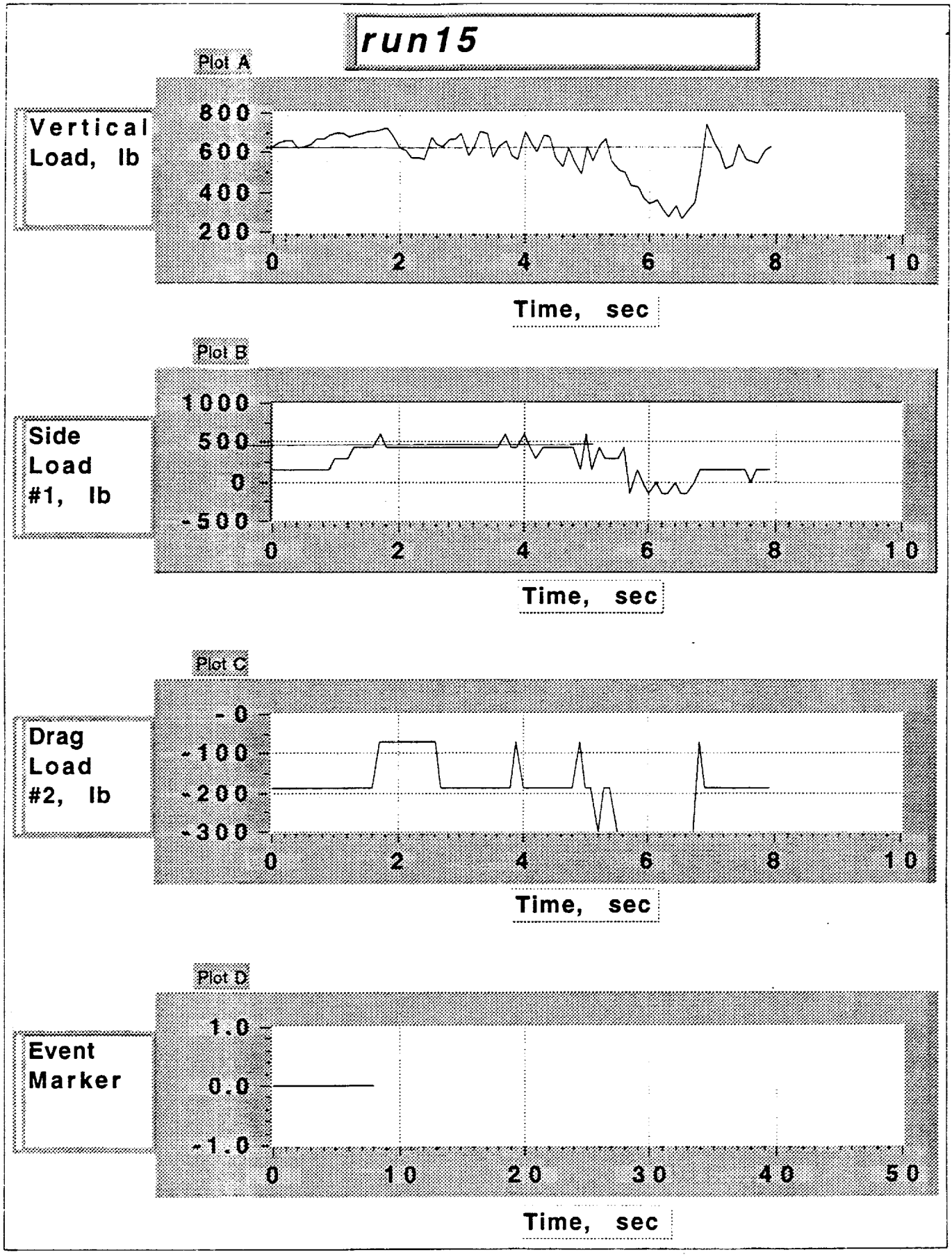

run10
Plot A
Vertical Load, lb
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

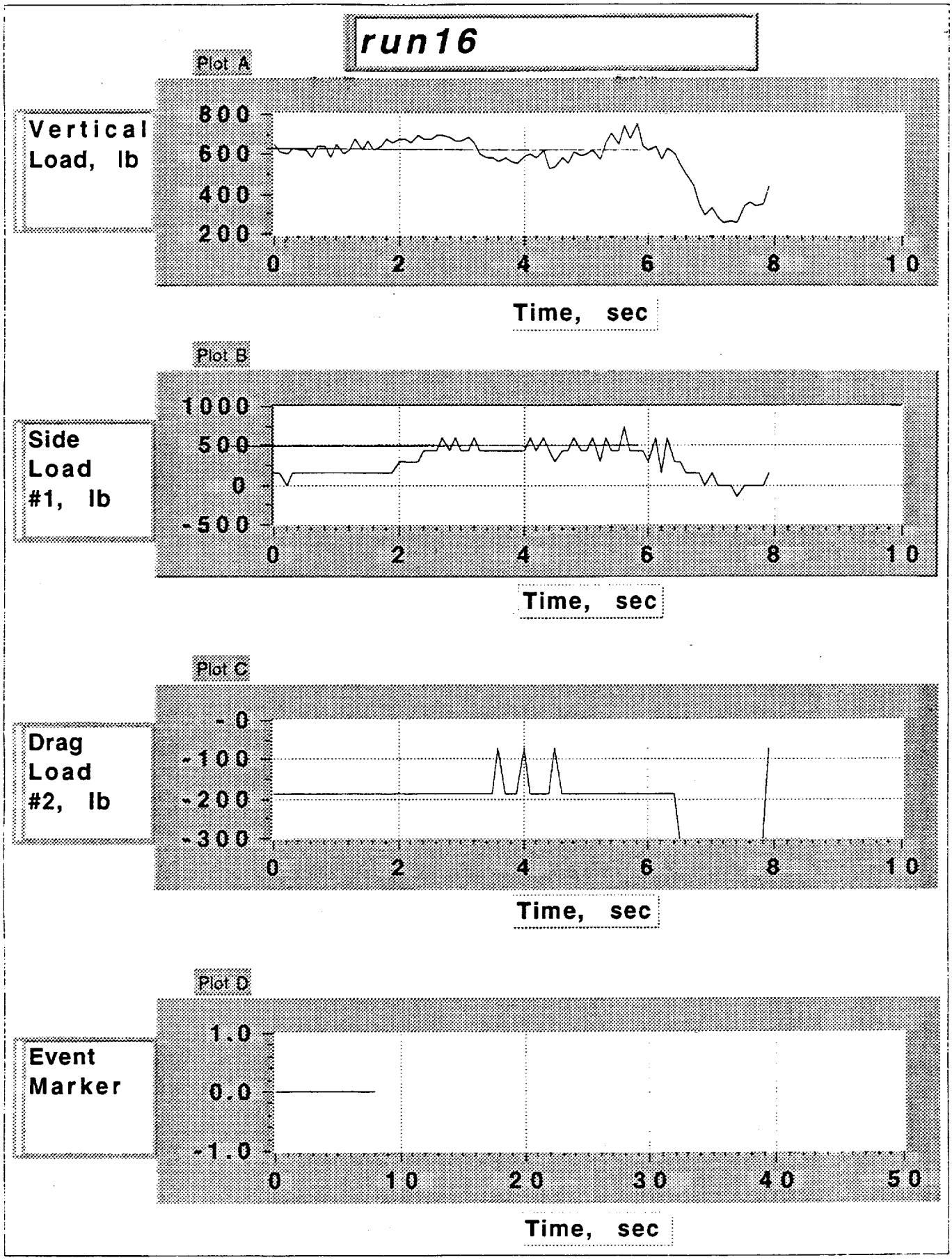

run11
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

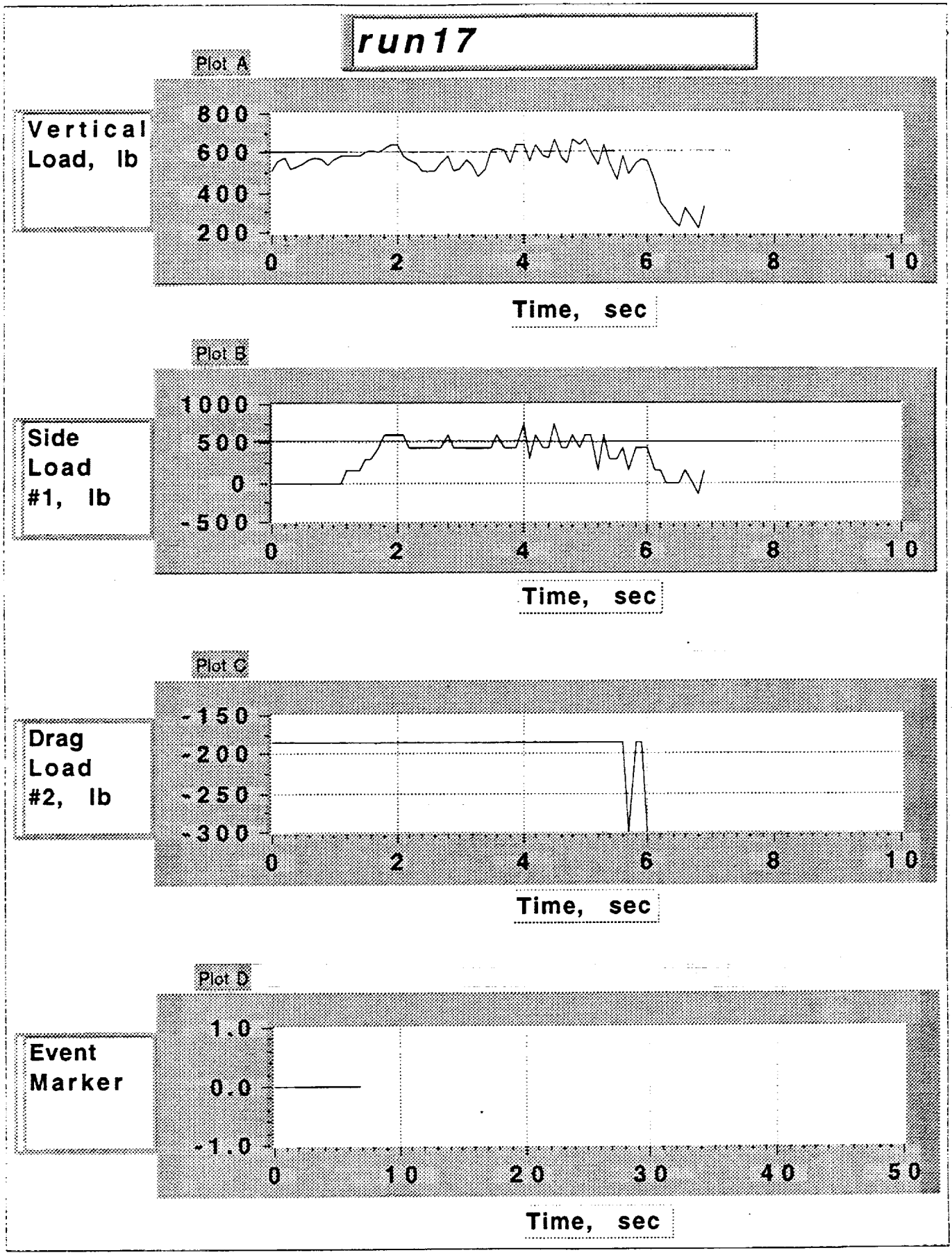

run12
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

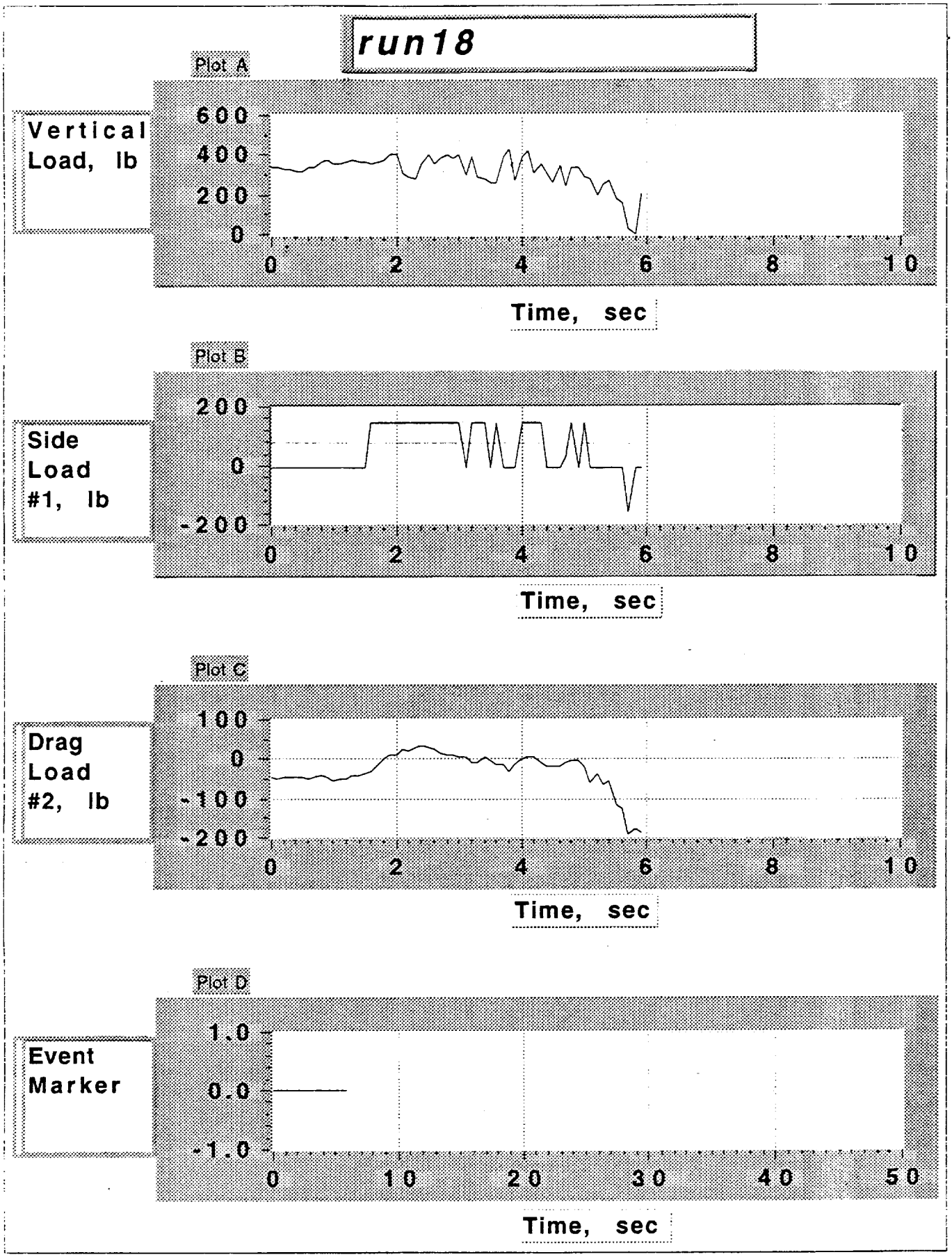

run13
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
- 0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

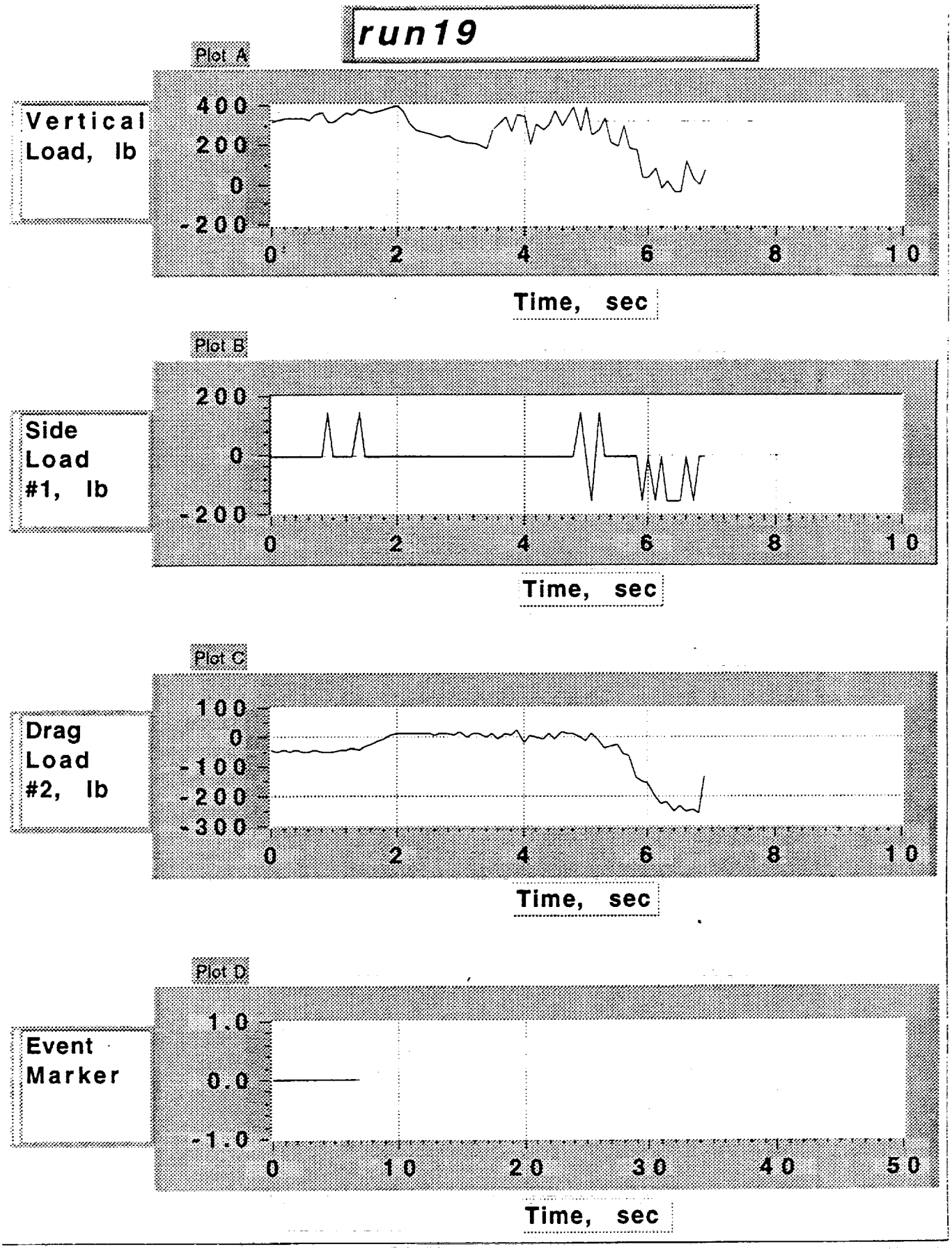

run14
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

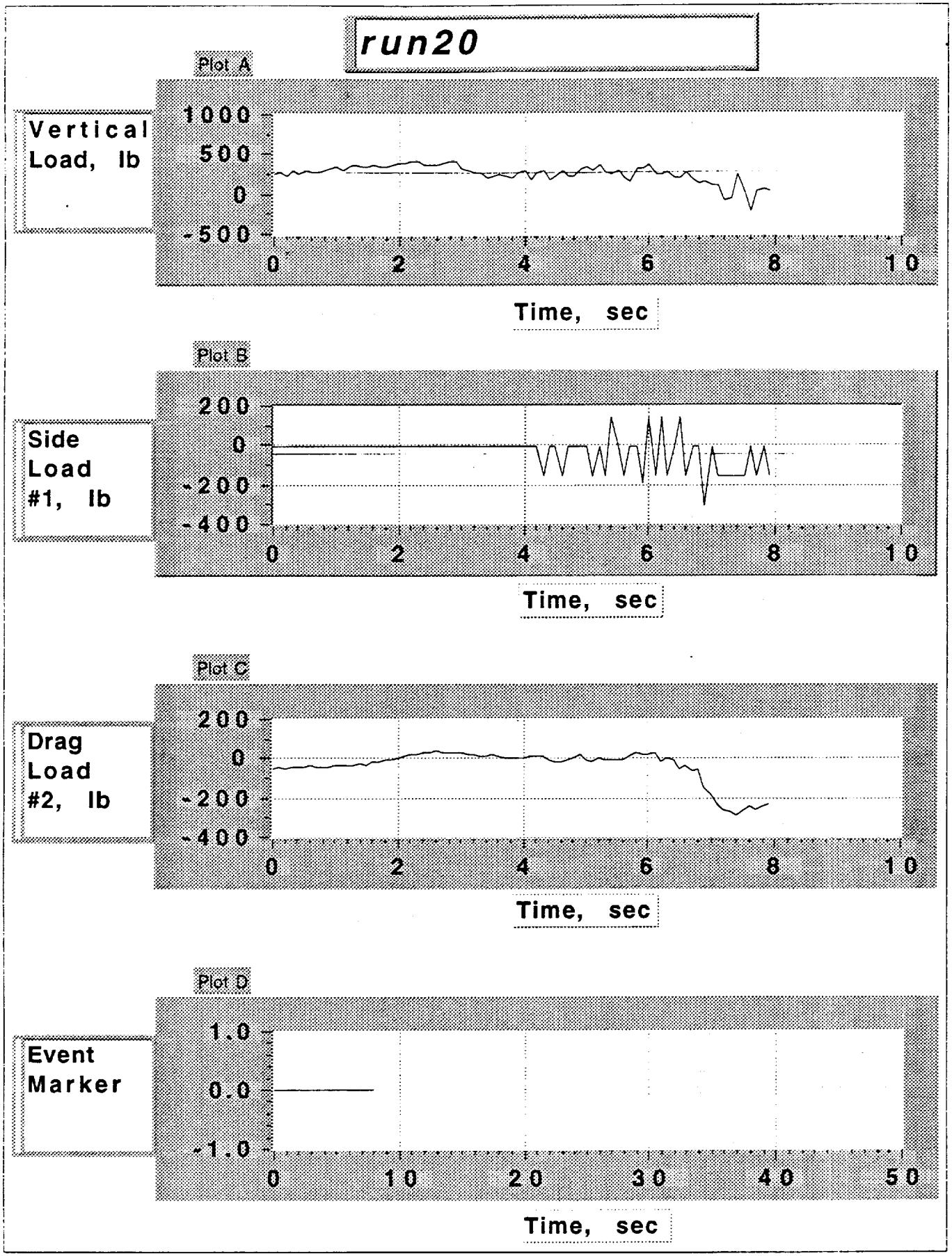

run15
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

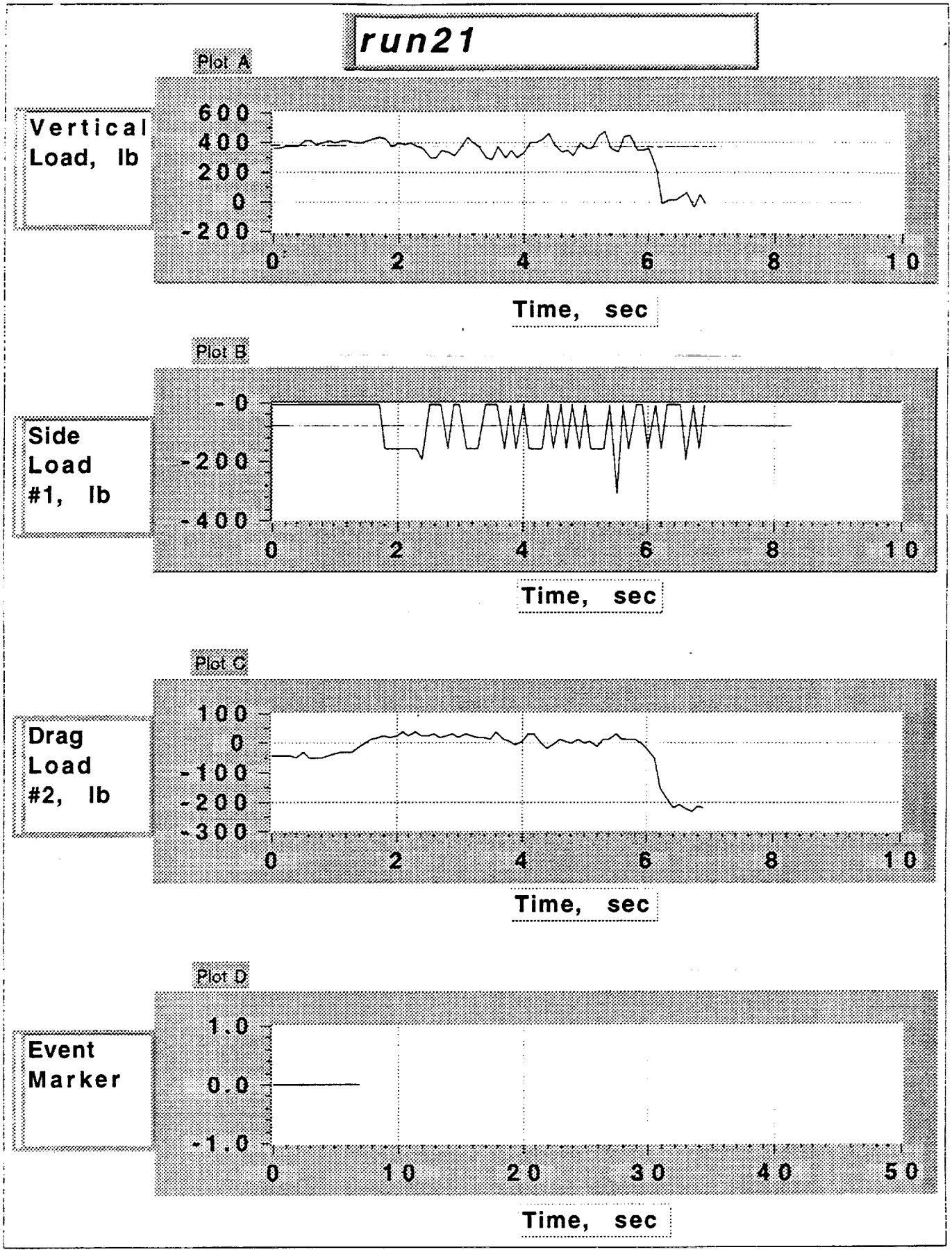

run16
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

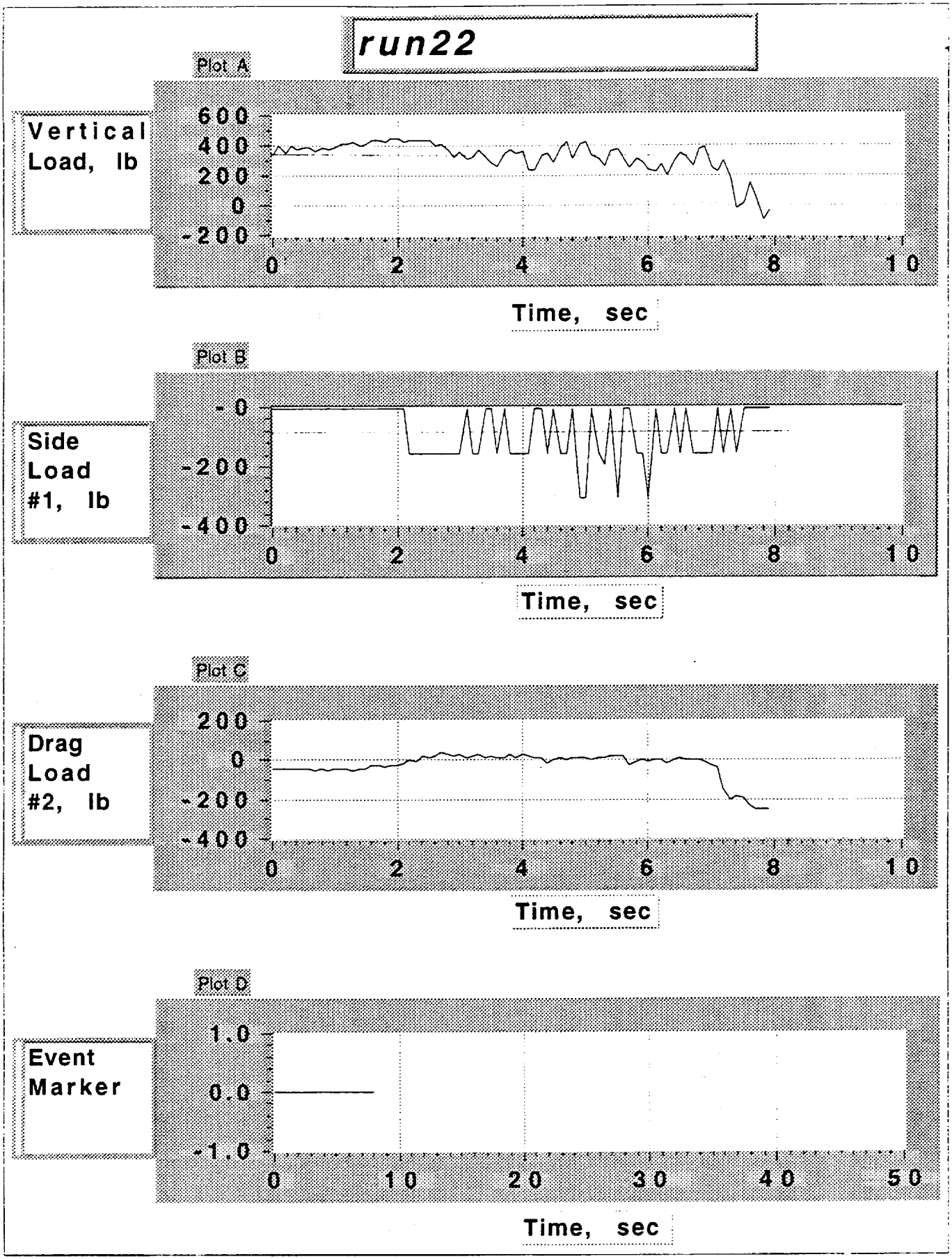

run17
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-150
-200
-250
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

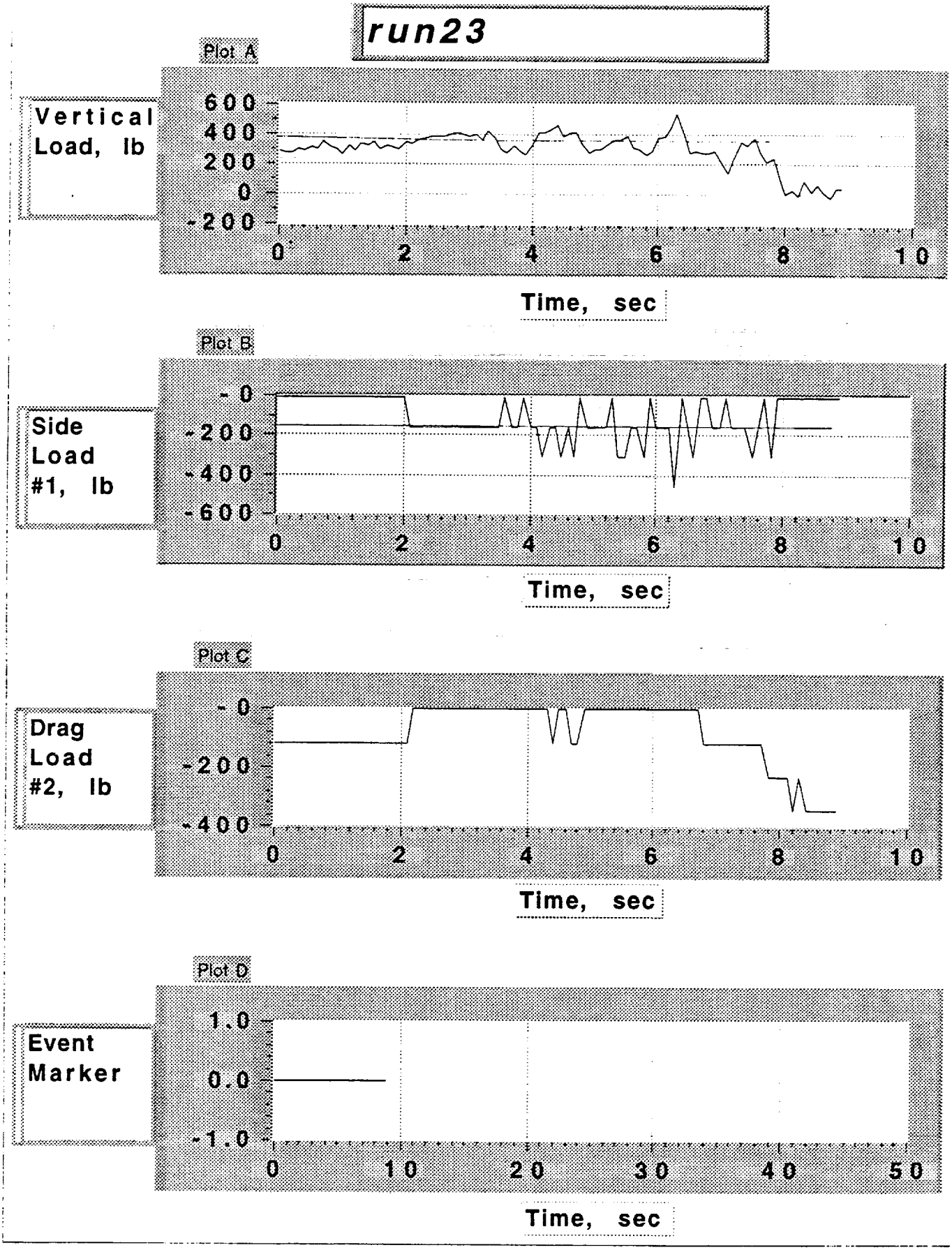

run18
Plot A
Vertical Load, lb
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

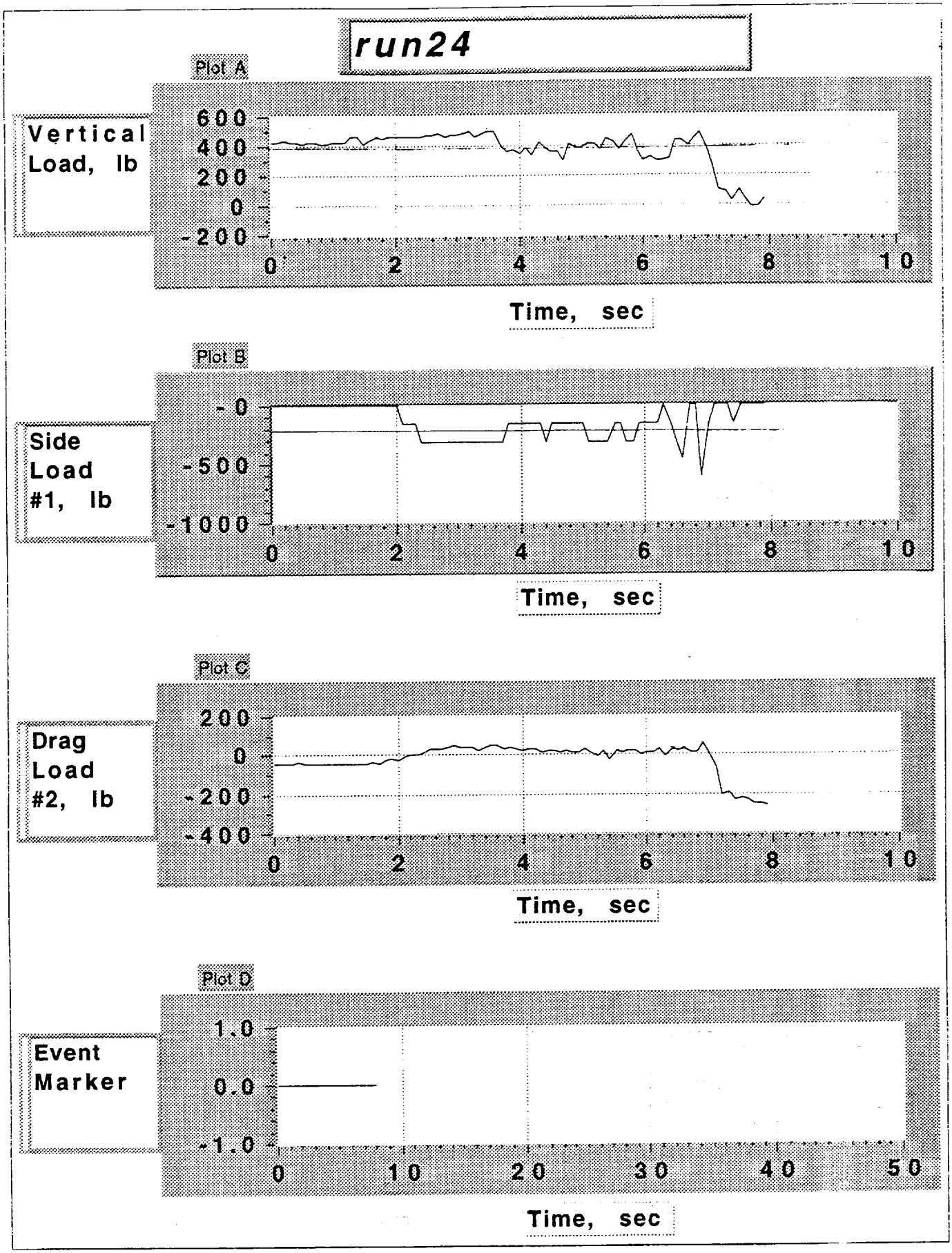

run19
Plot A
Vertical Load, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

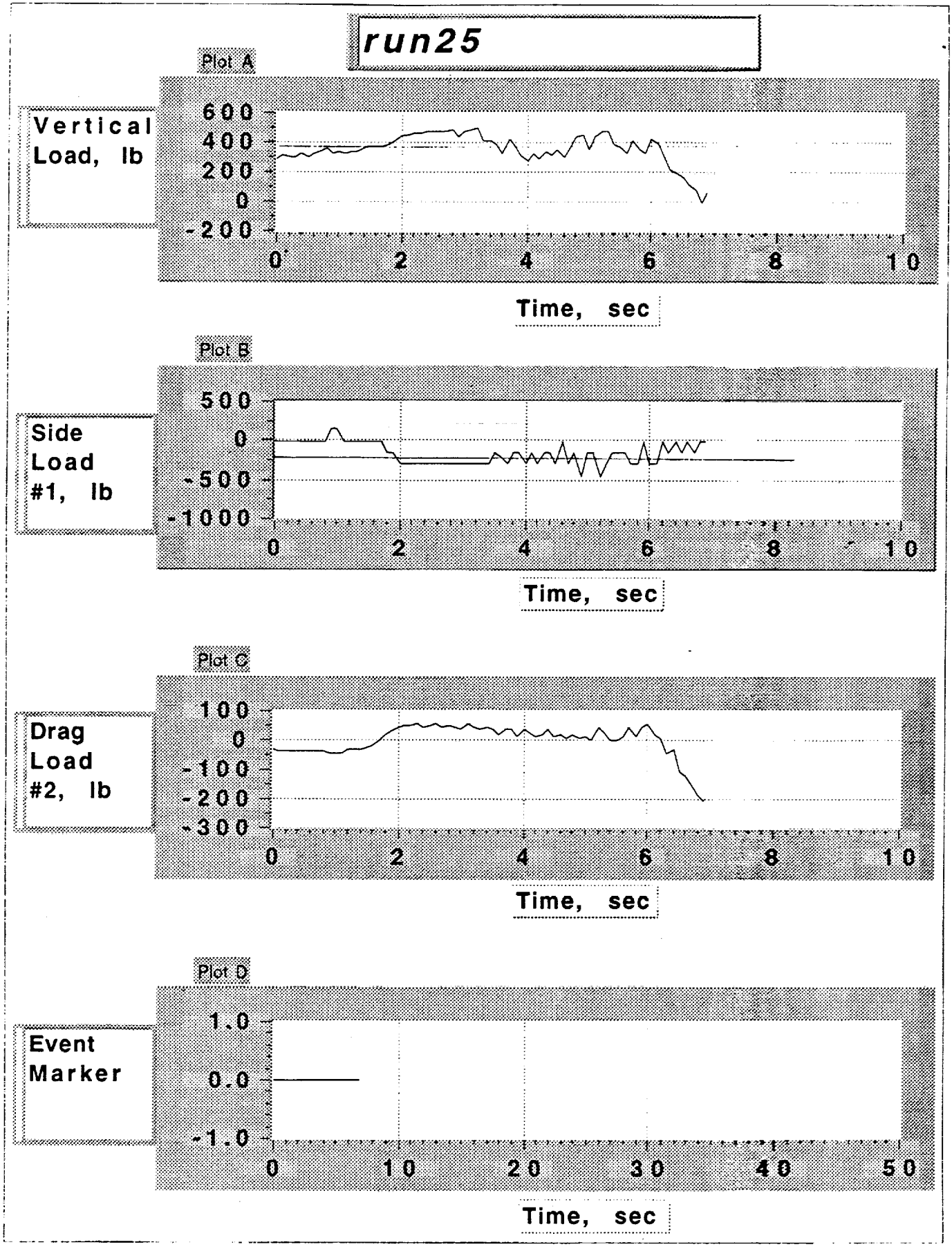

run20
Plot A
Vertical Load, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

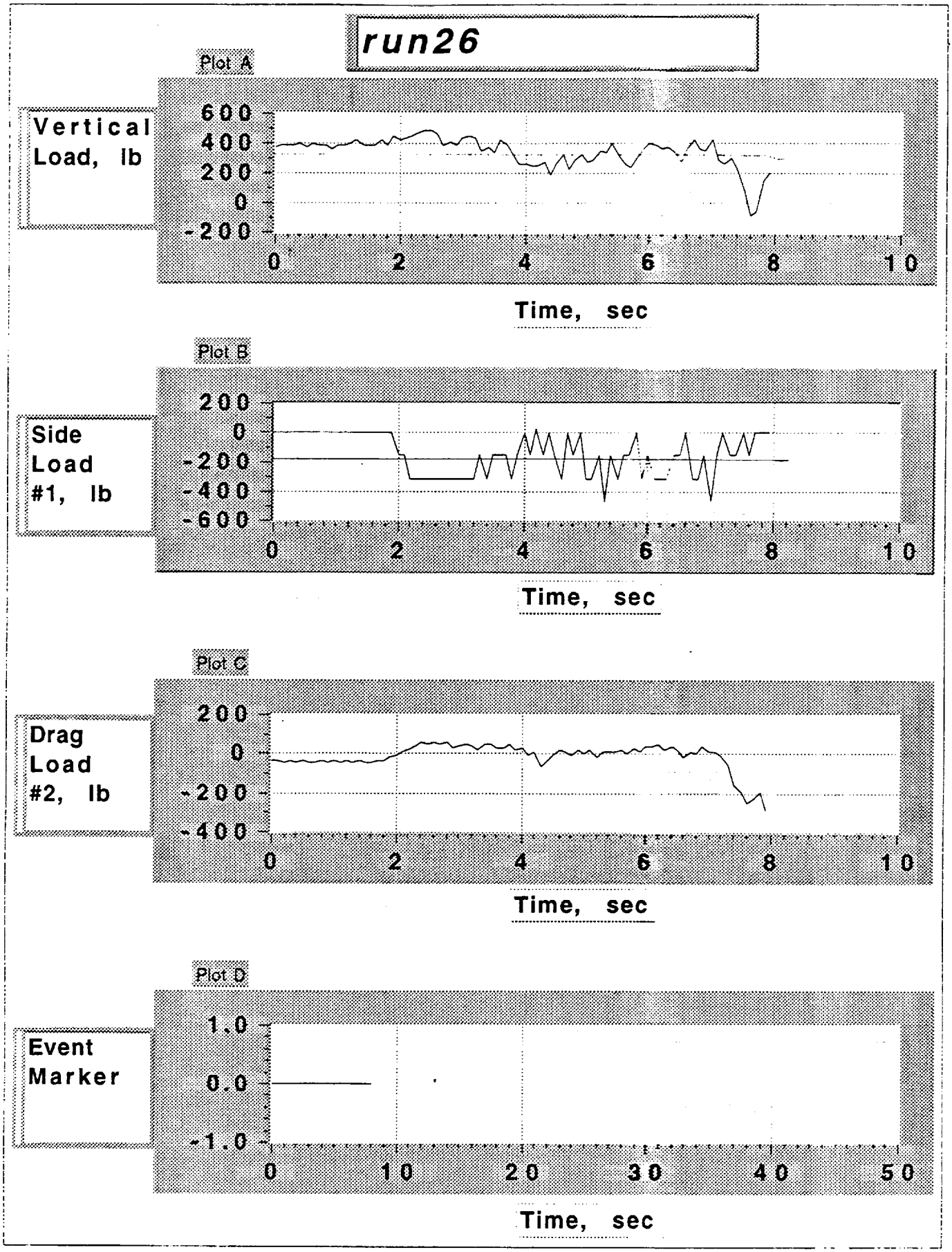

run21
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

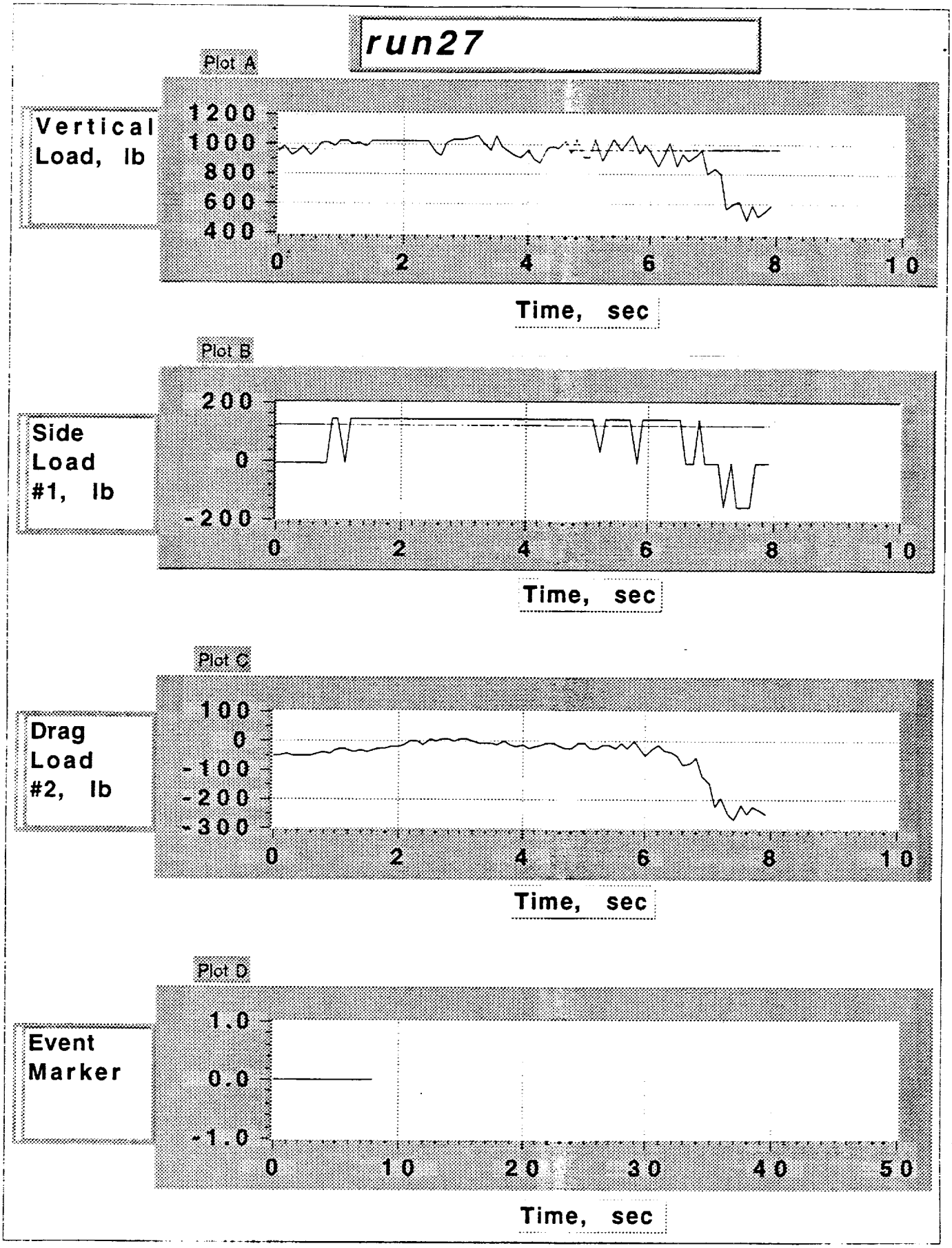

run22
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

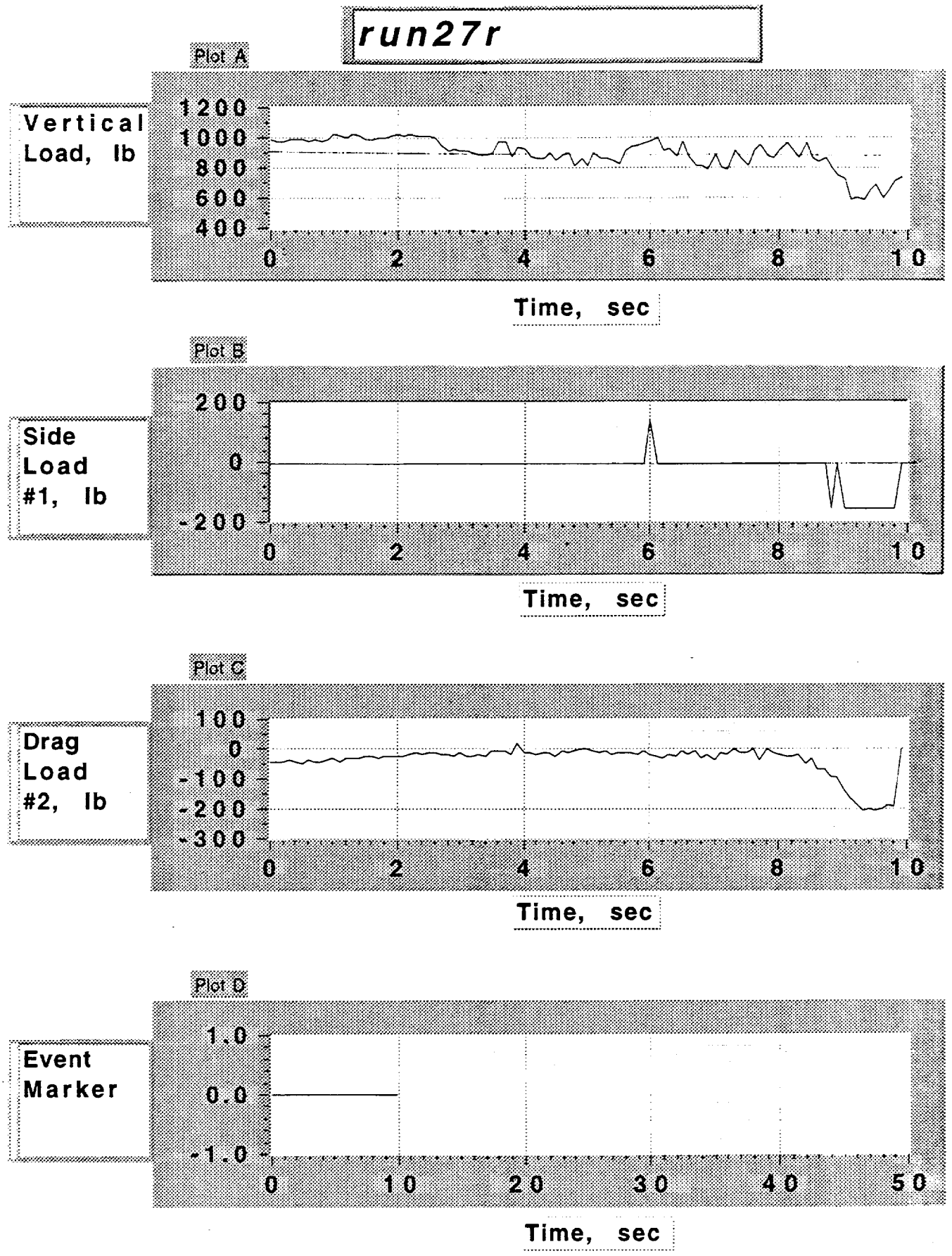

run23
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
-600
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

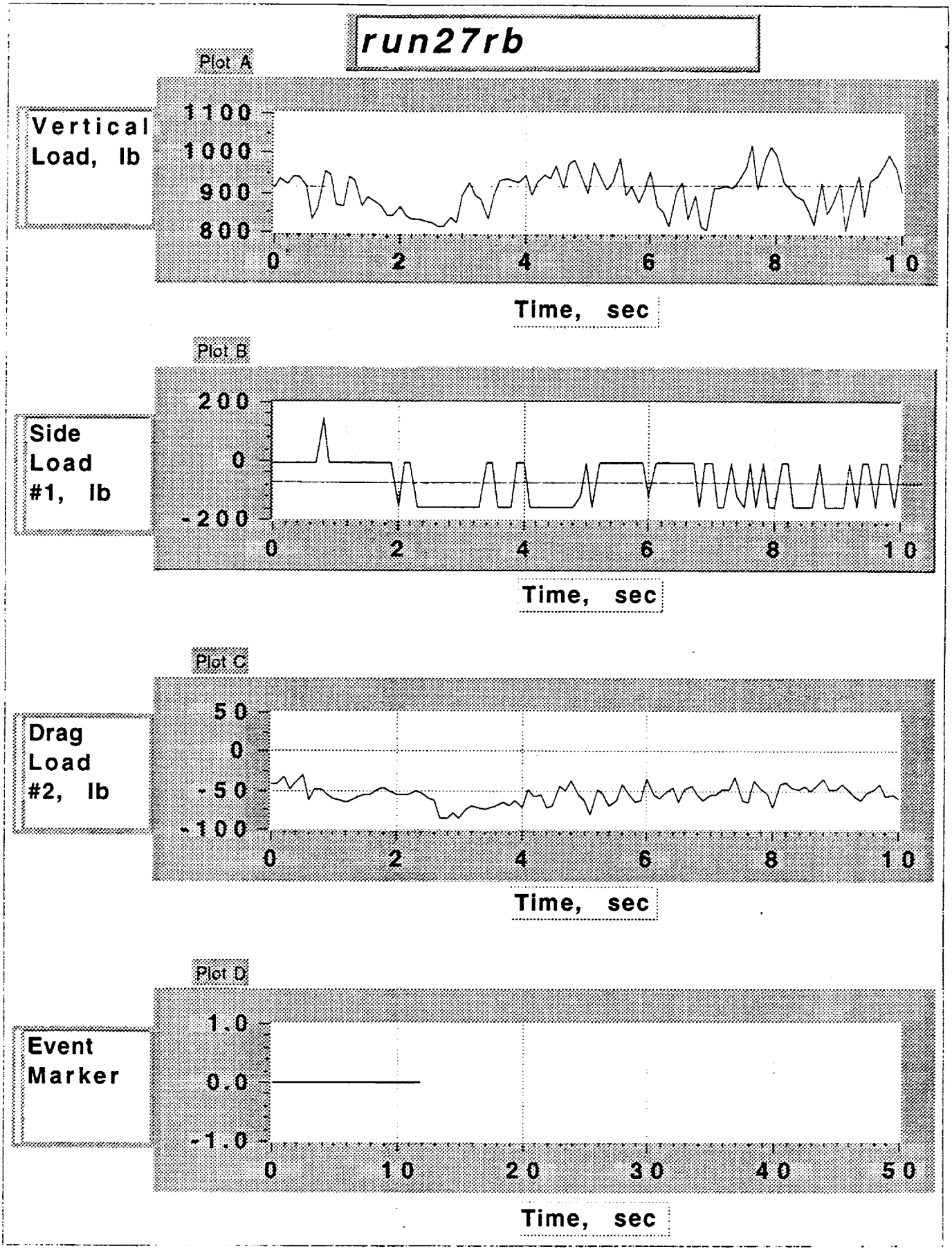

run24
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

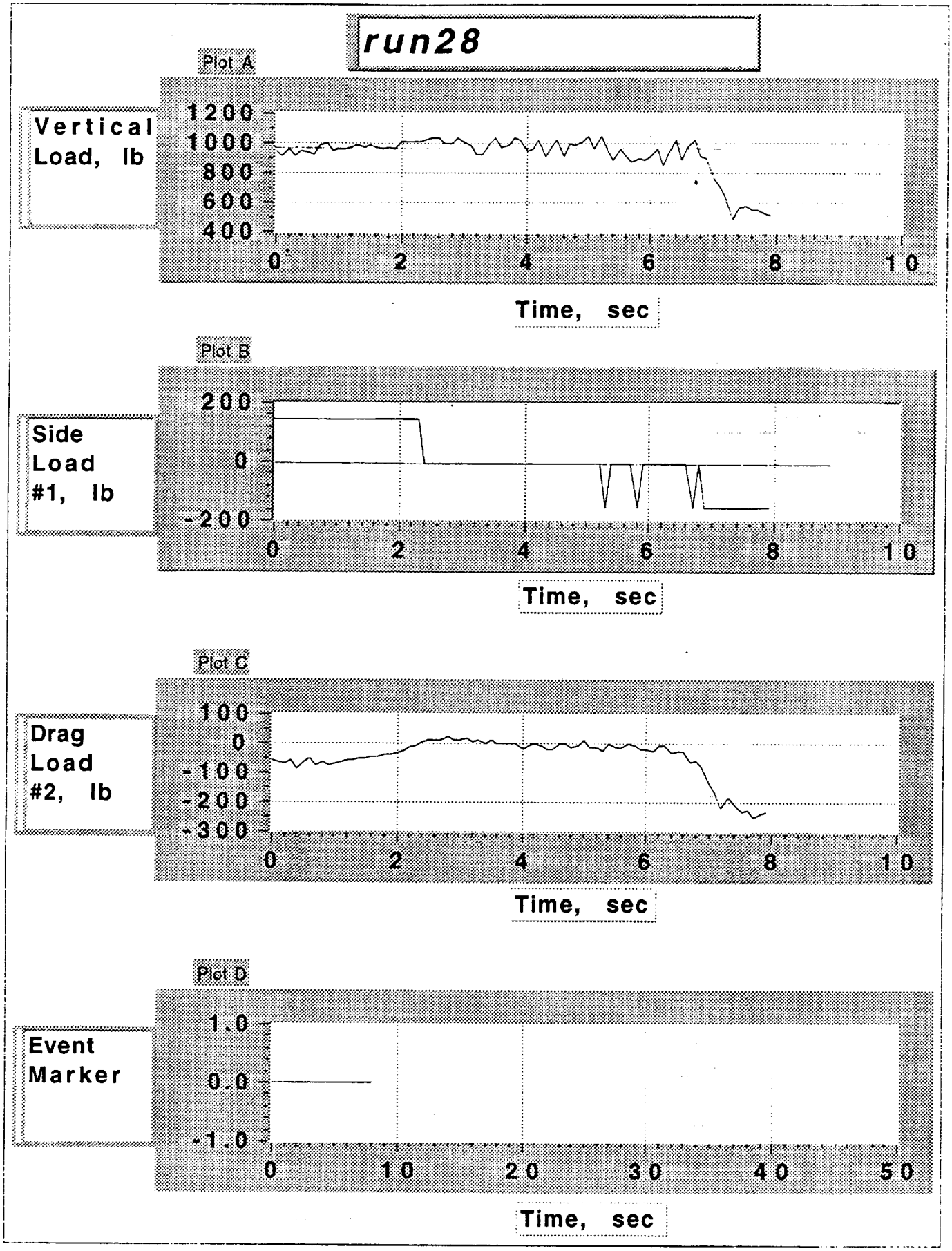

run25
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

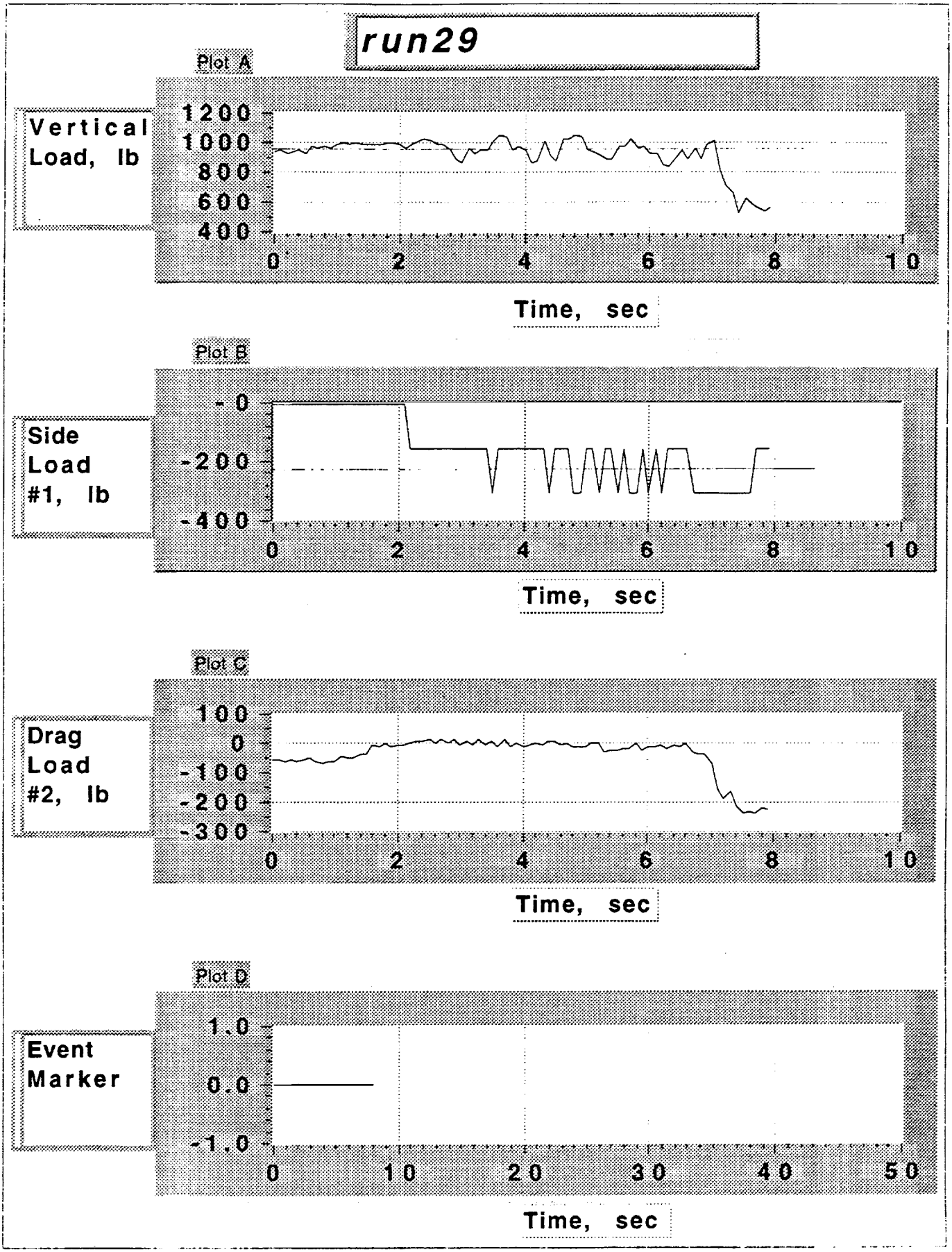

run26
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
-400
-600
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

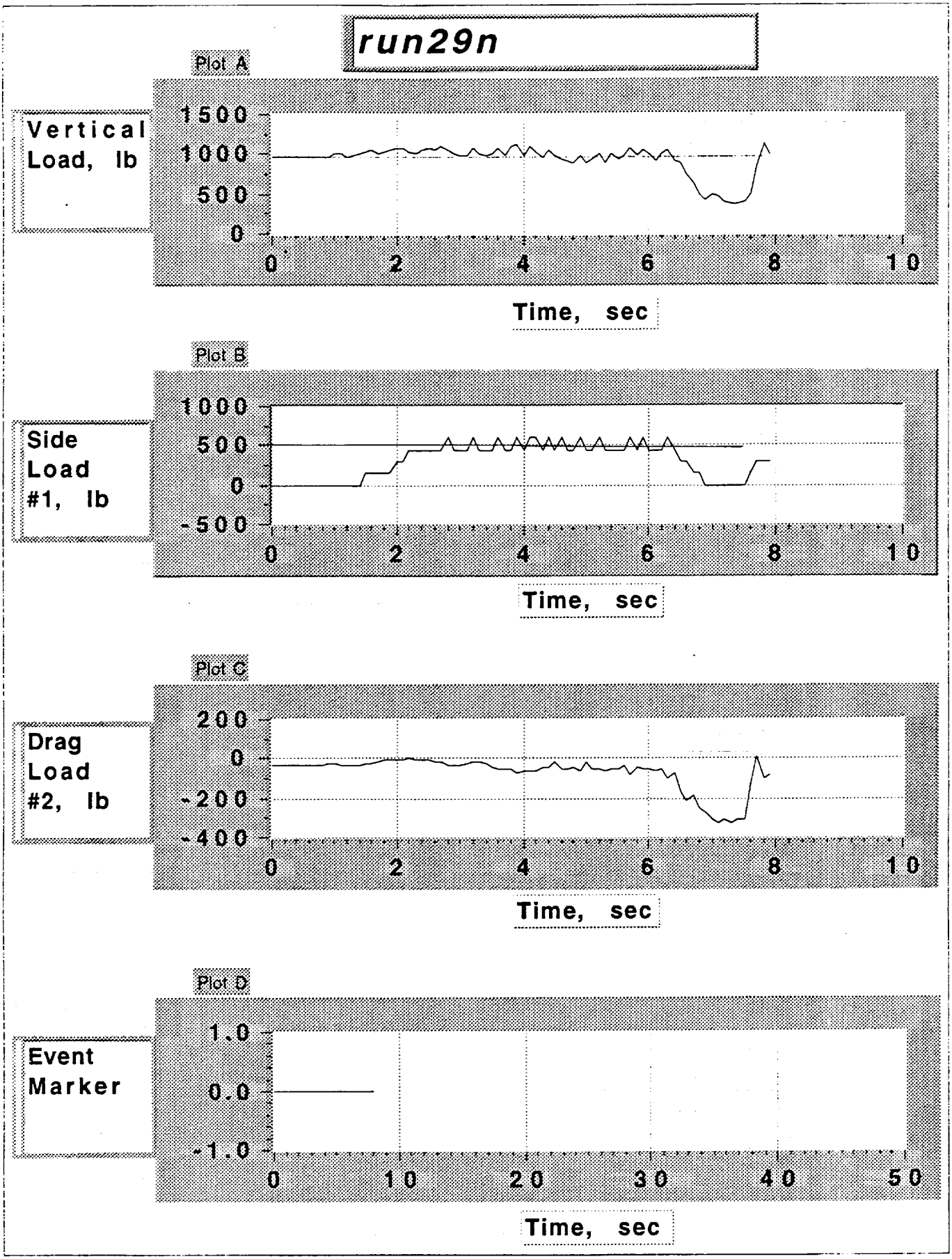

run27
Plot A
Vertical Load, lb
1200
1000
800
600
400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

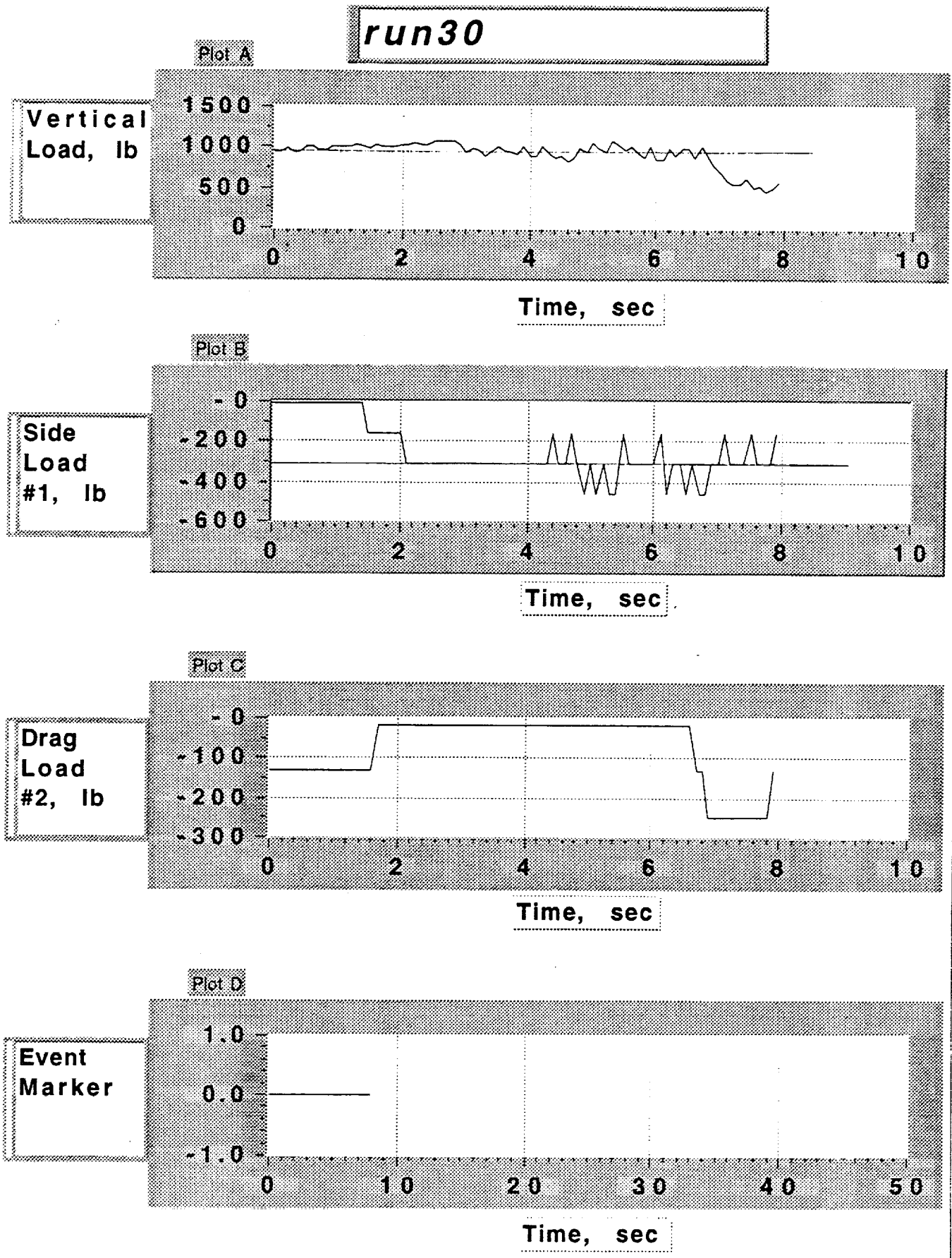

run27r
Plot A
Vertical Load, lb
1200
1000
800
600
400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

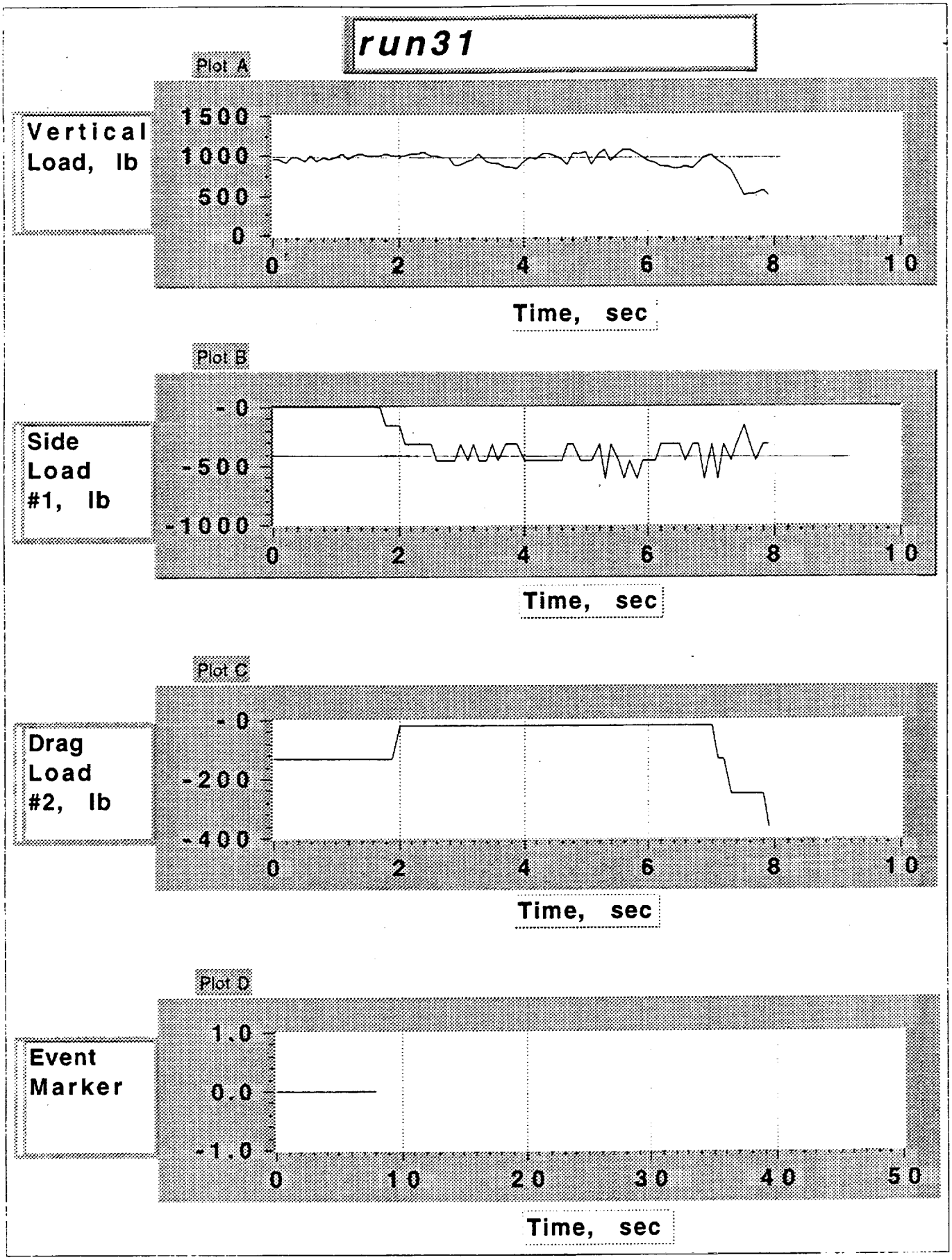

run27rb
Plot A
Vertical Load, lb
1100
1000
900
800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
50
0
-50
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

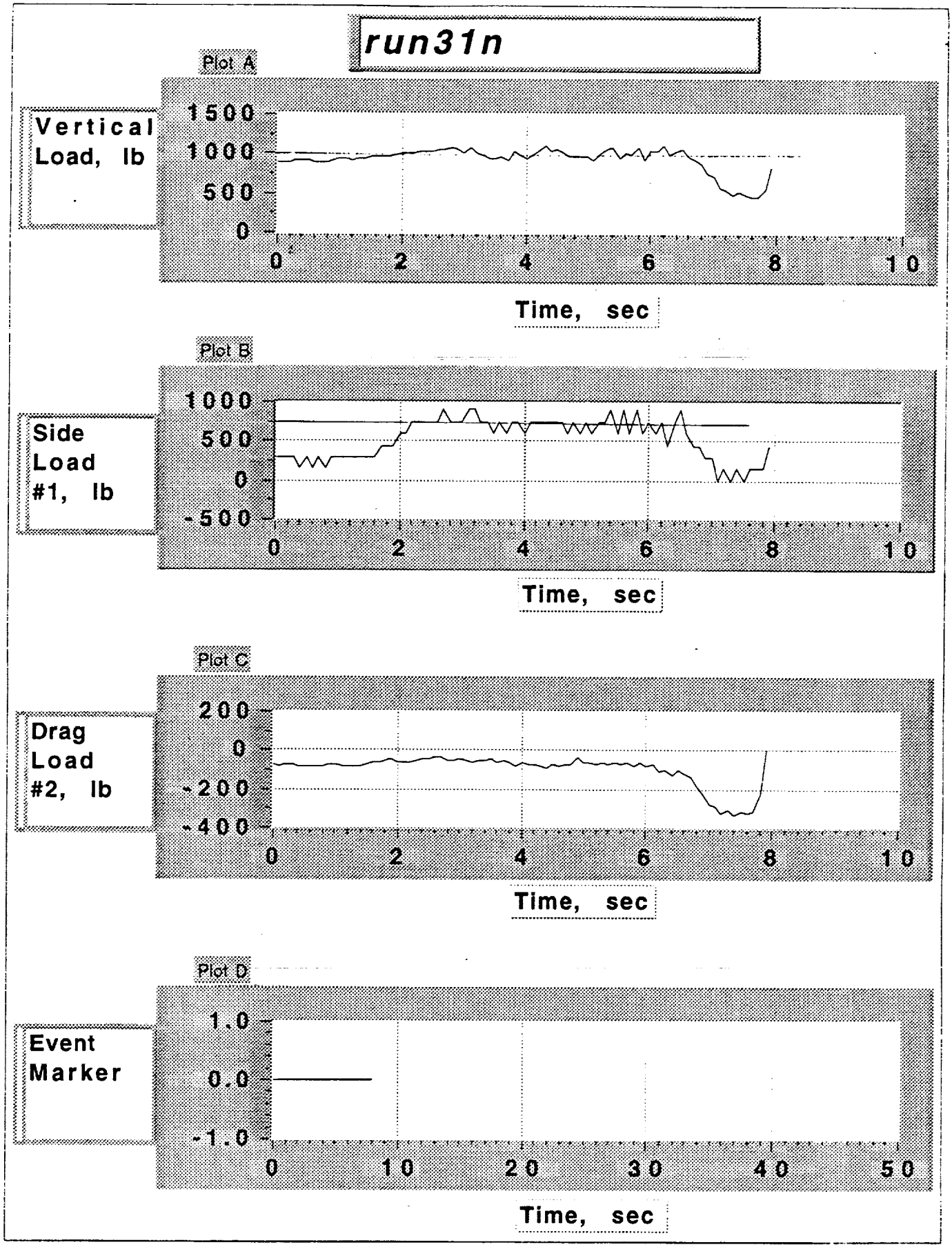

run28
Plot A
Vertical Load, lb
1200
1000
800
600
400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

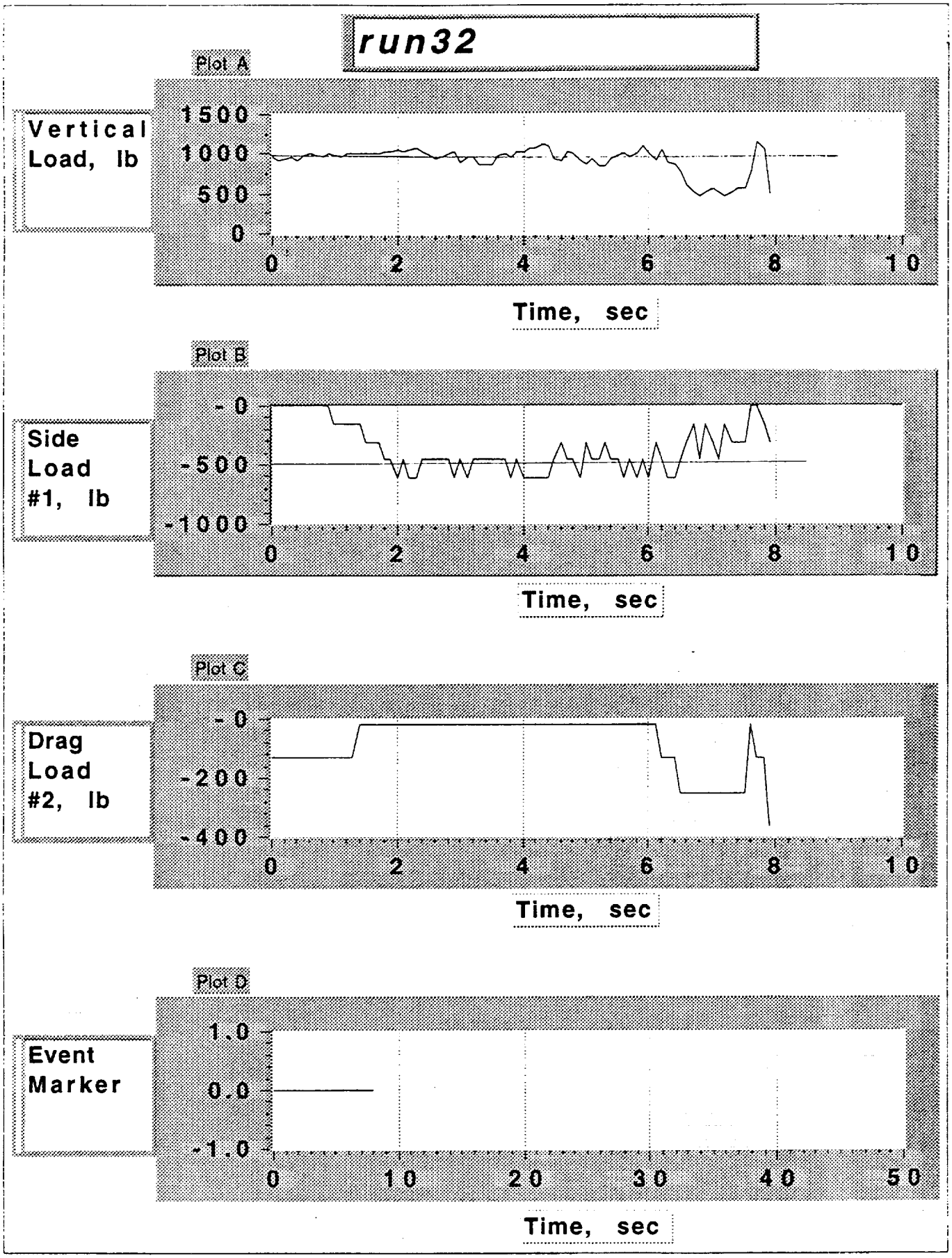

run29
Plot A
Vertical Load, lb
1200
1000
800
600
400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

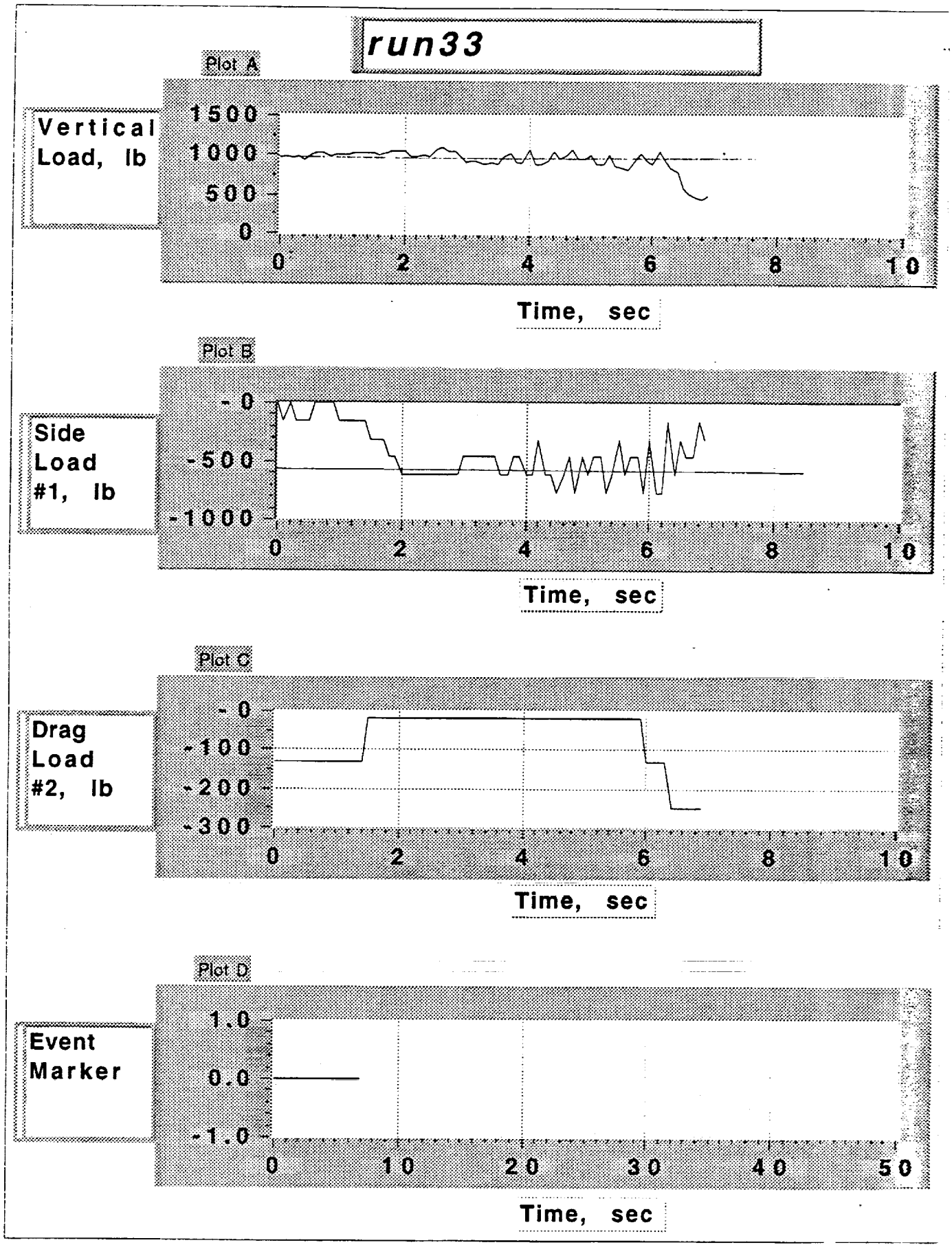

run29n
Plot A
Vertical Load, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

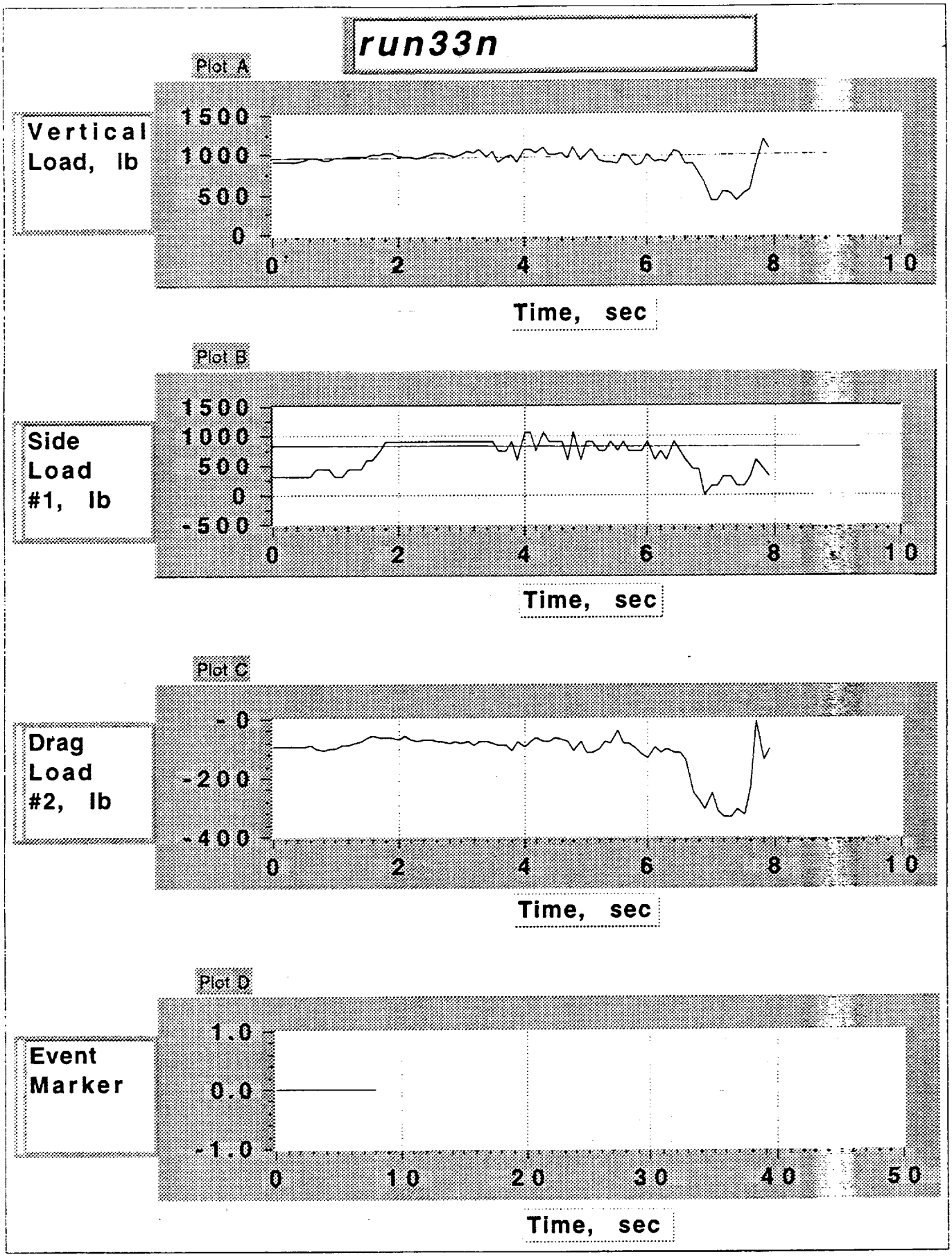

run30
Plot A
Vertical Load, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
-600
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

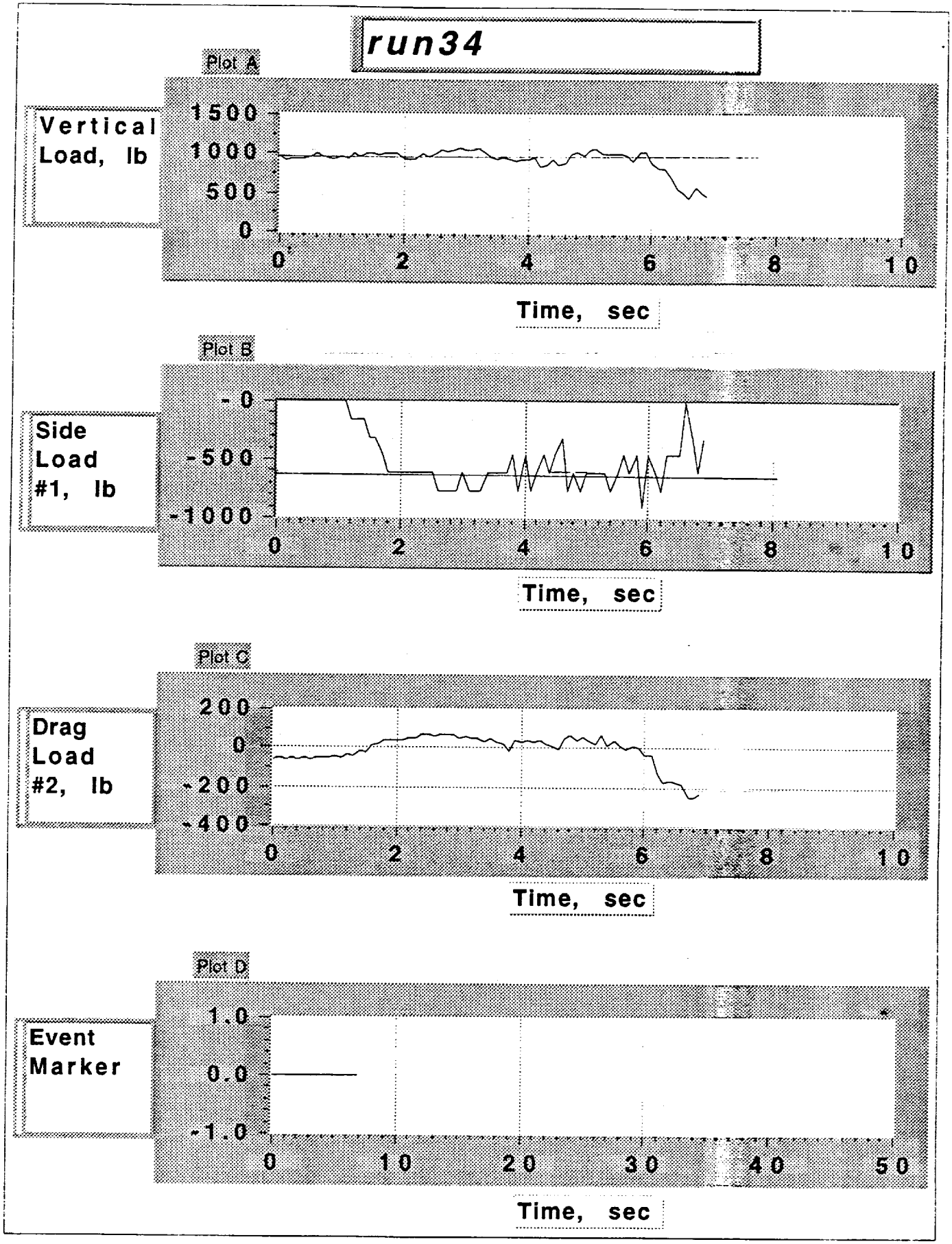

run31
Plot A
Vertical Load, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

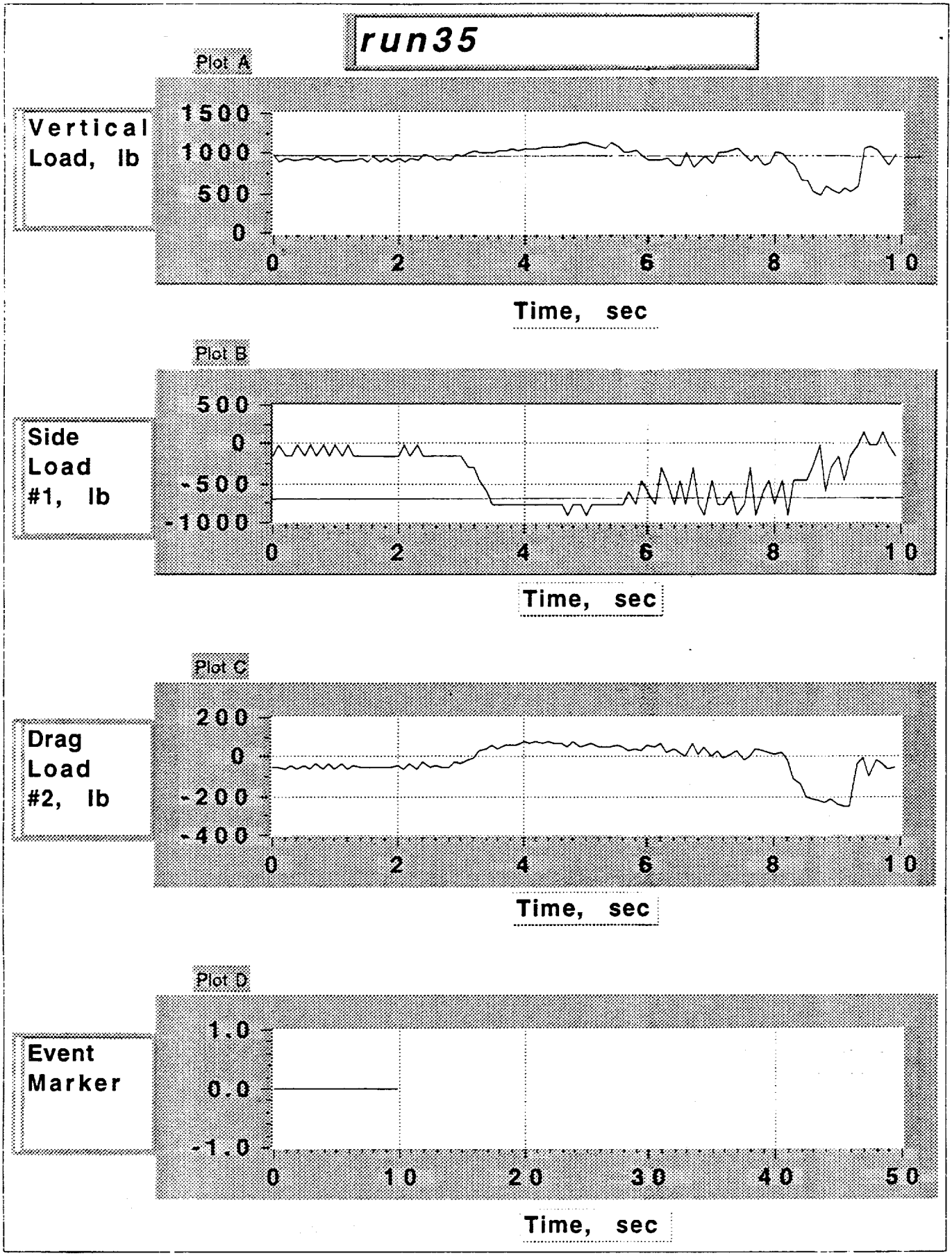

run31n
Plot A
Vertical Load, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

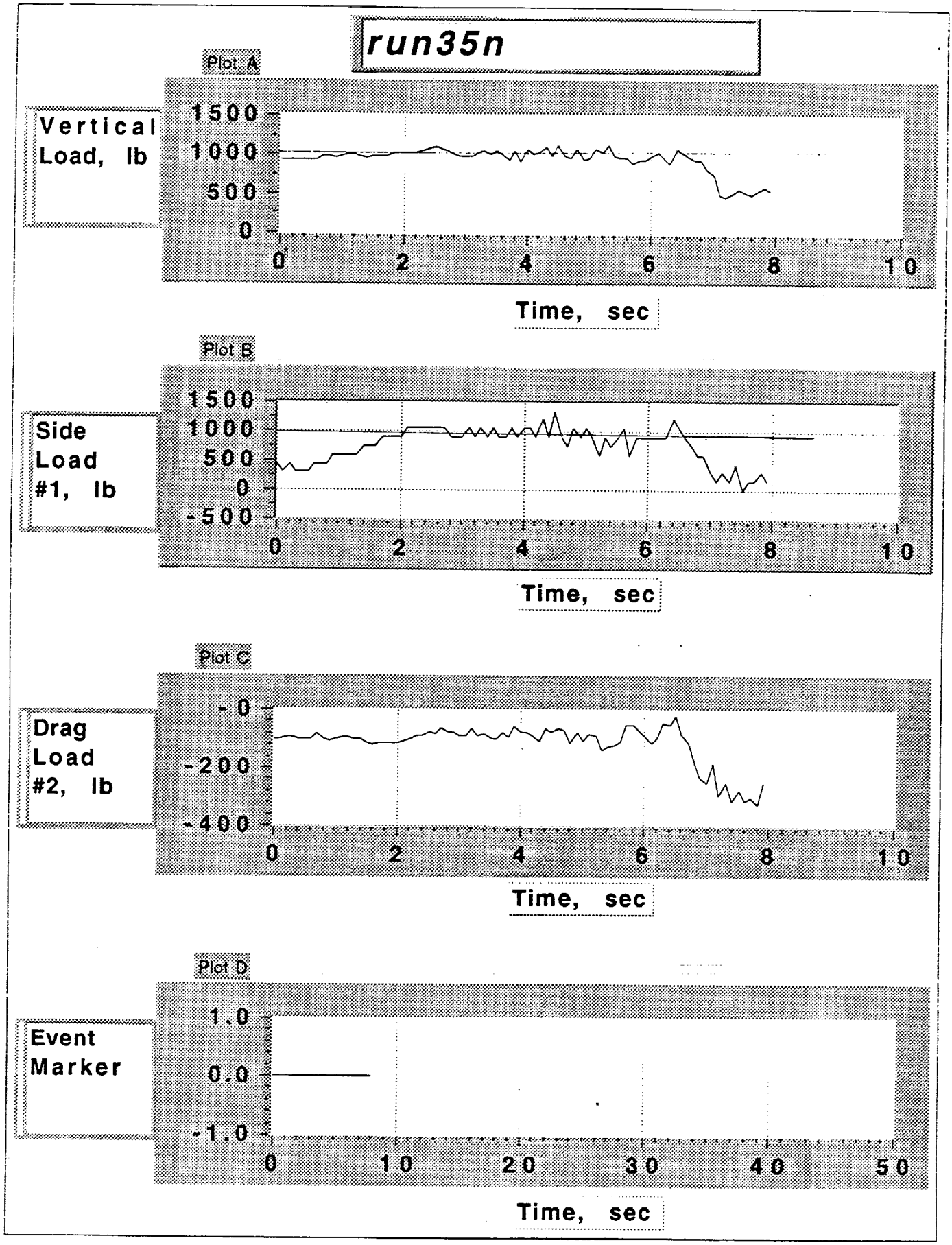

run32
Plot A
Vertical Load, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

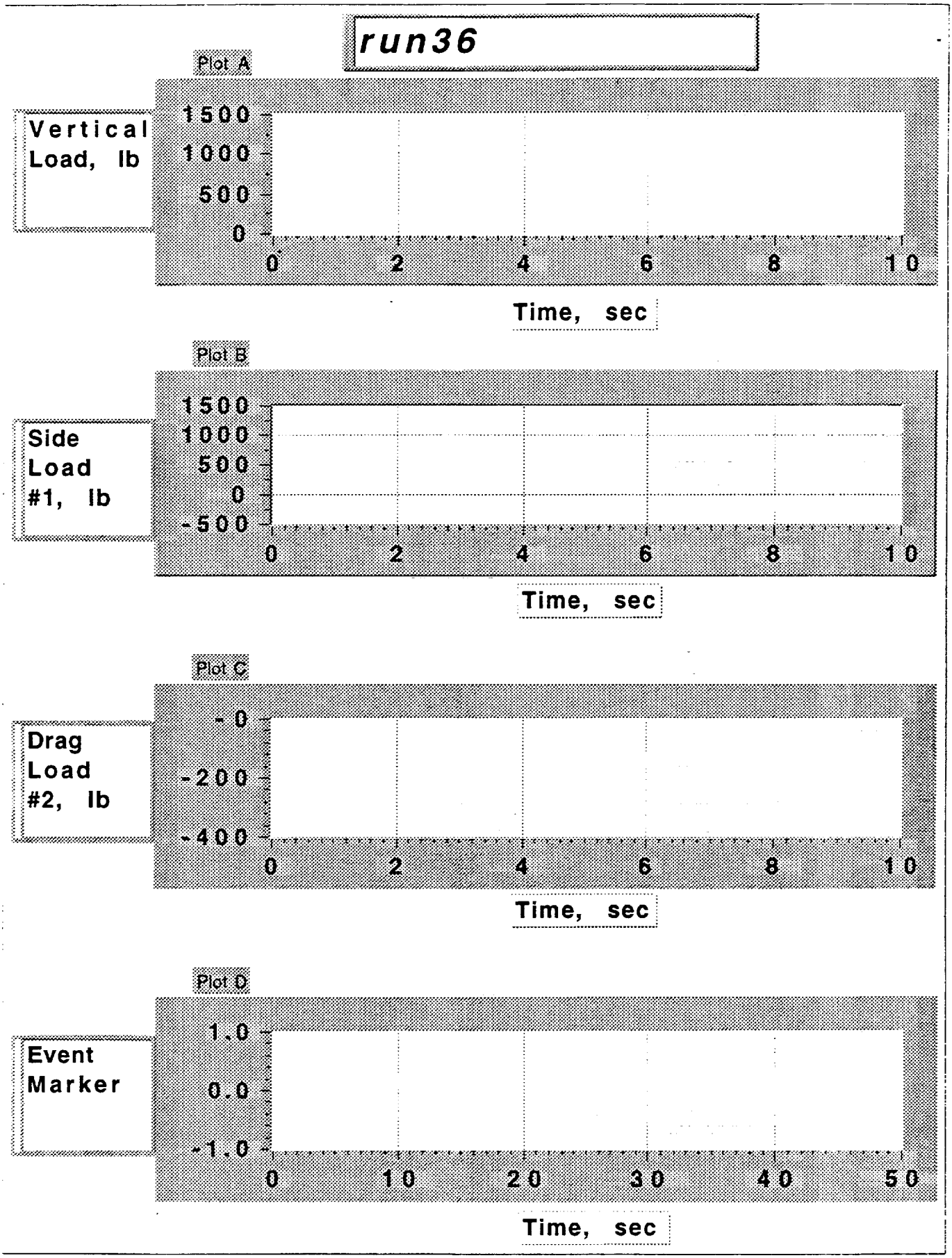

run33
Plot A
Vertical Load, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
- 0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
- 0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

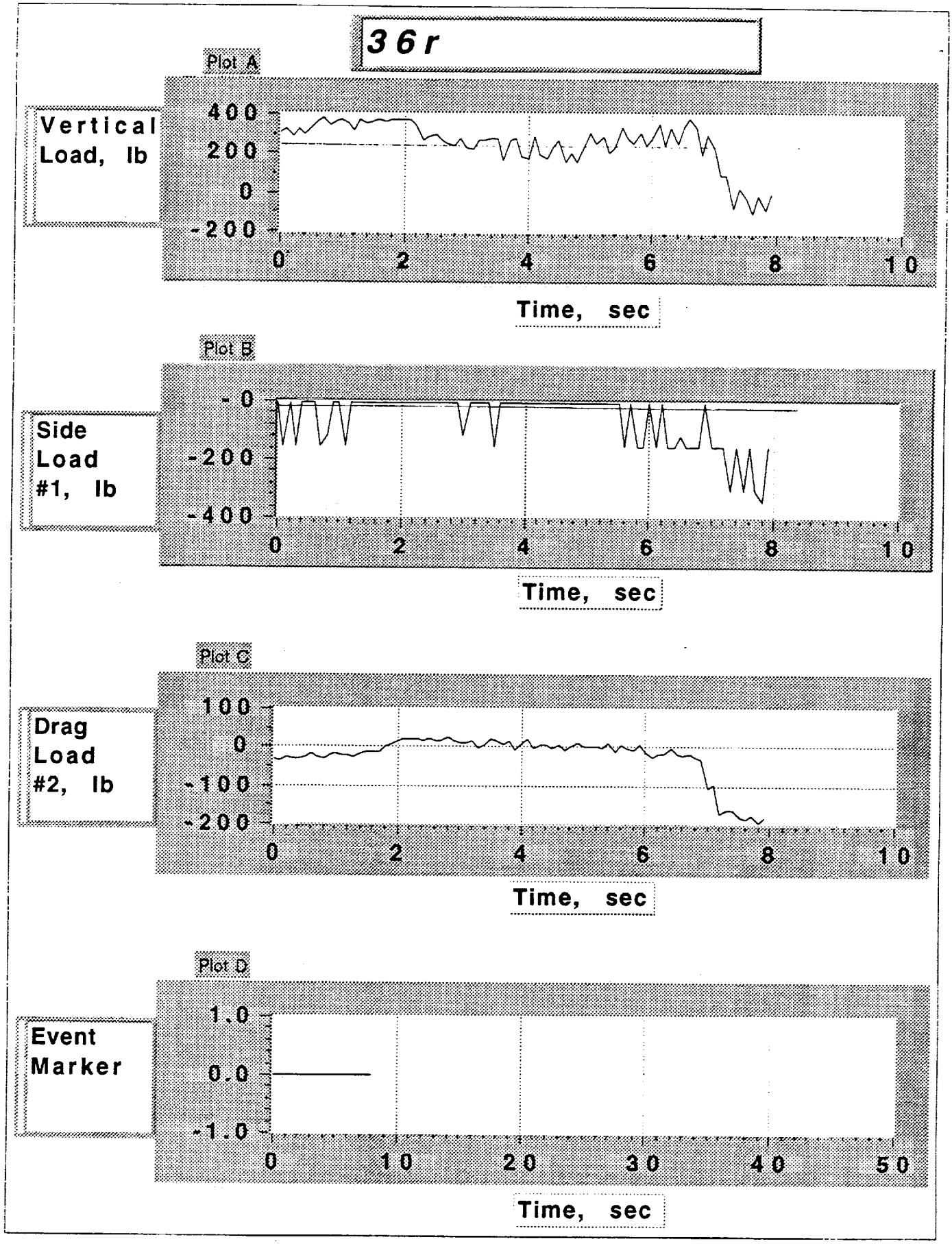

run33n
Plot A
Vertical Load, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1500
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

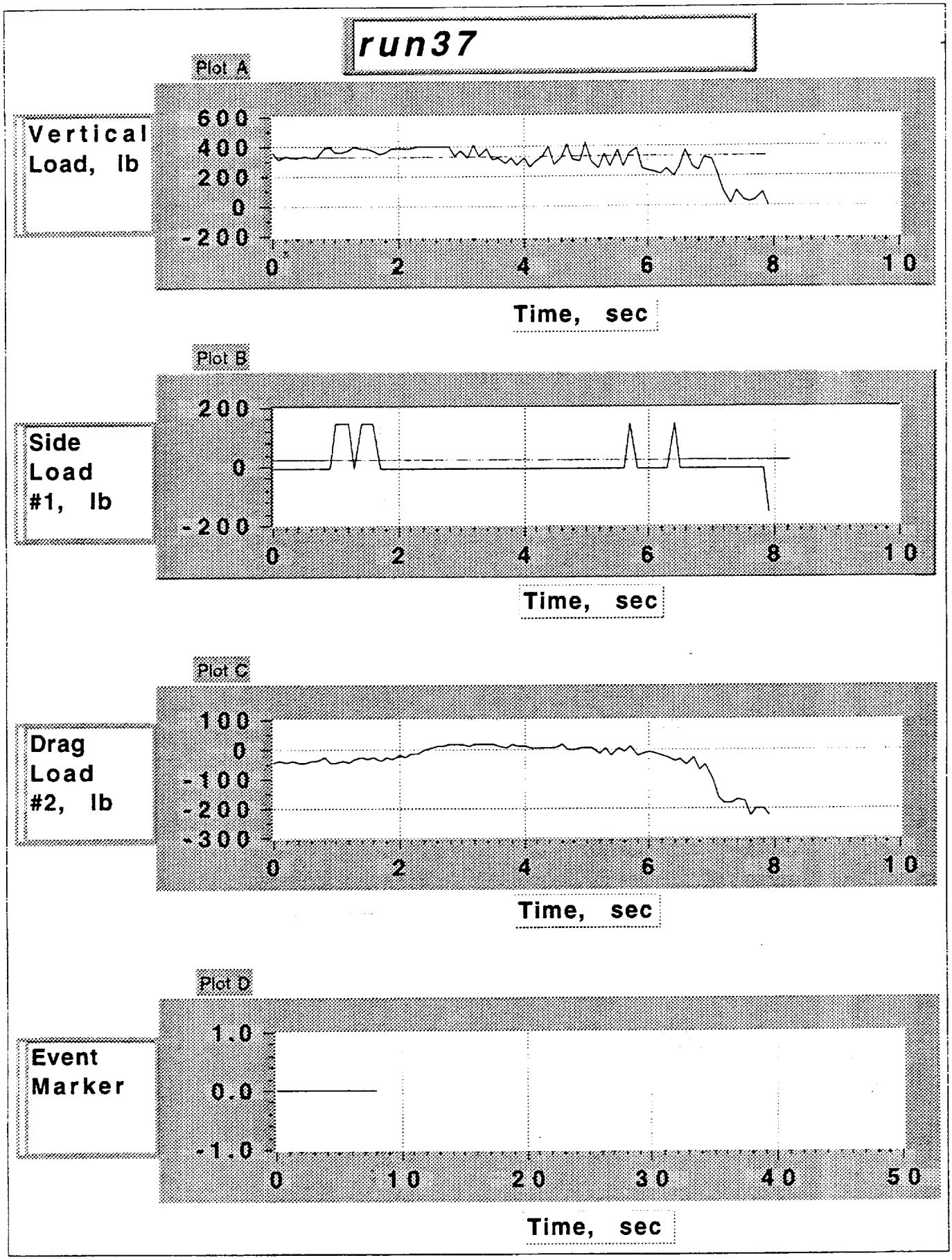

run34
Plot A
Vertical Load, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
- 0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

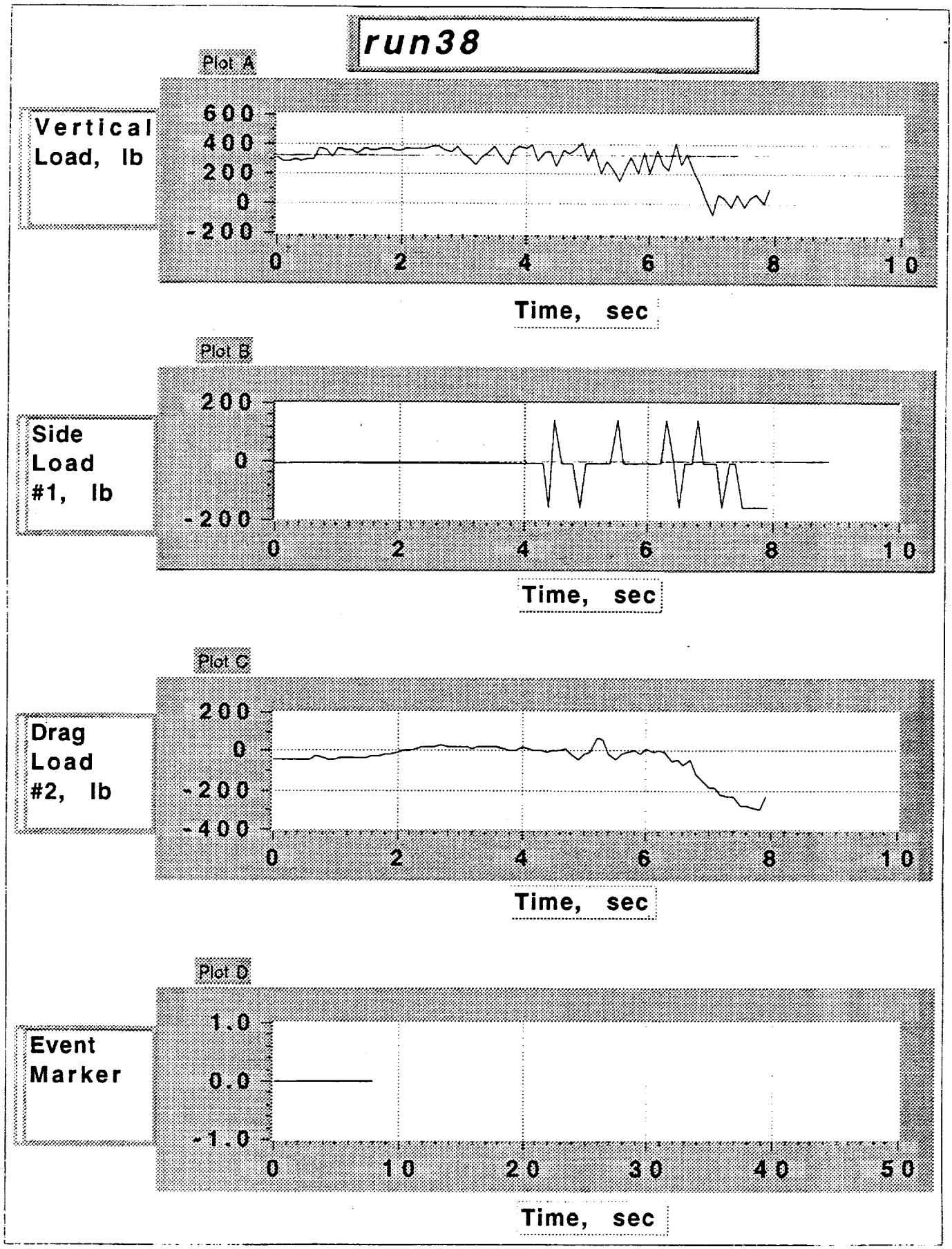

run35
Plot A
Vertical Load, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

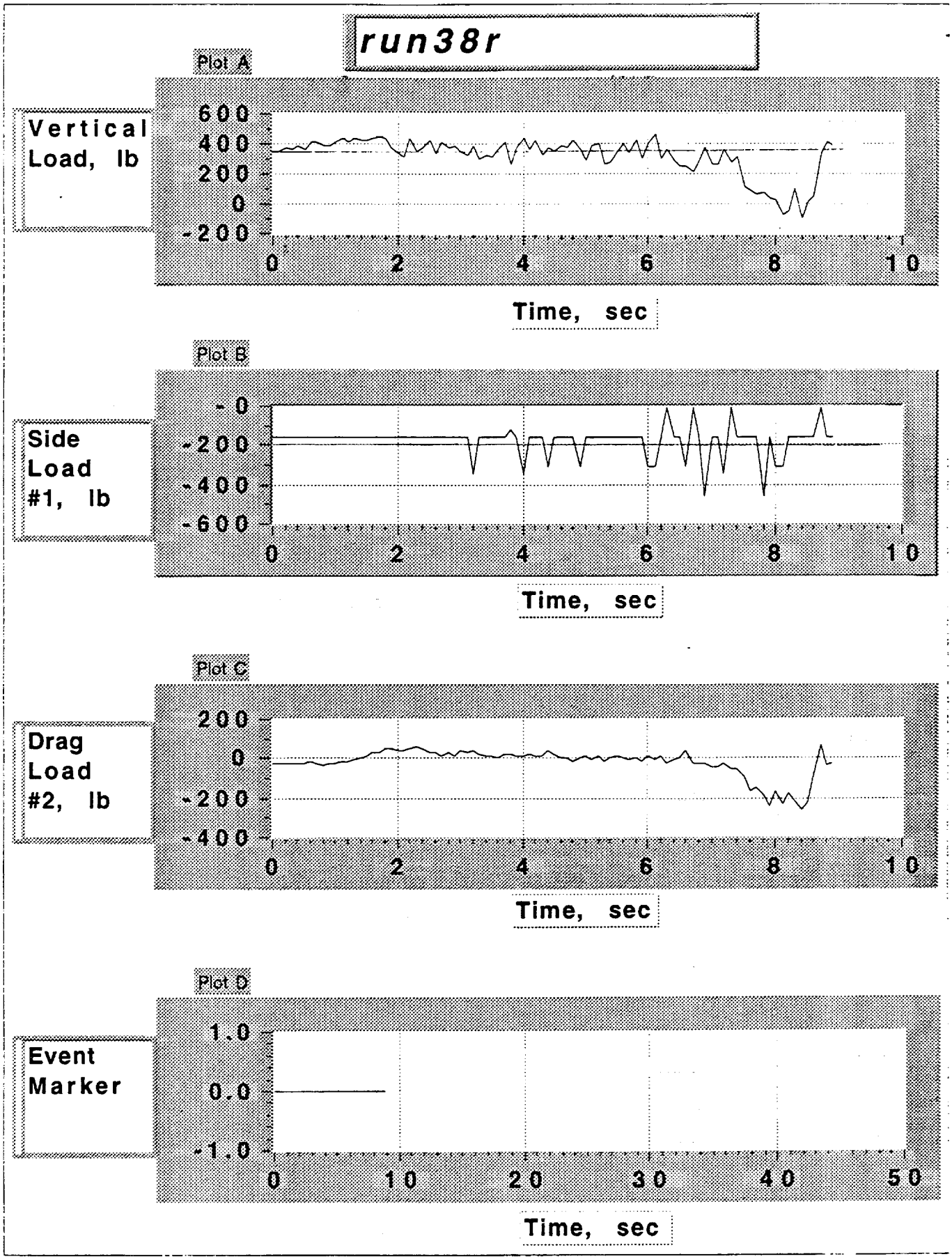

run35n
Plot A
Vertical Load, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1500
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

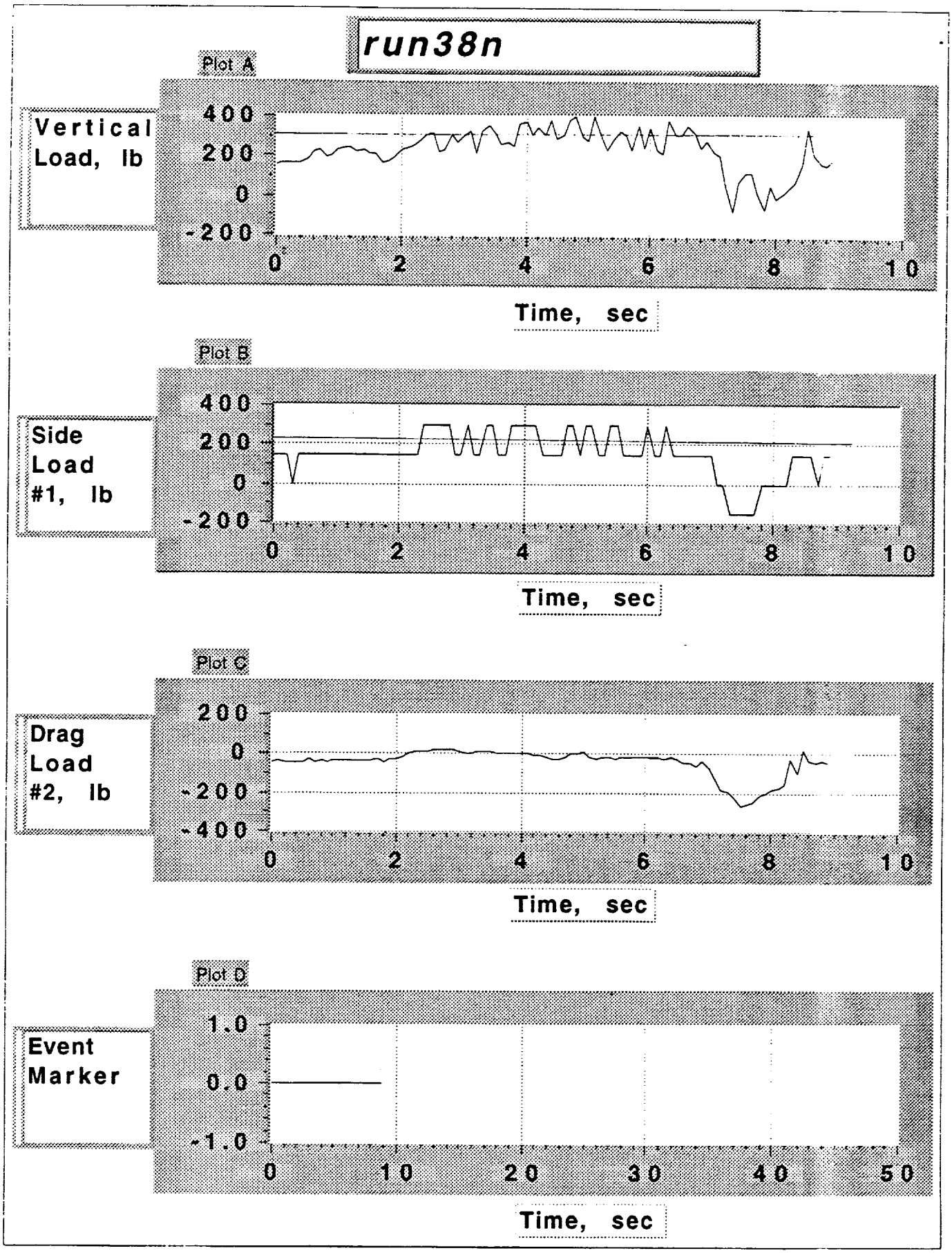

run36
Plot A
Vertical Load, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1500
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

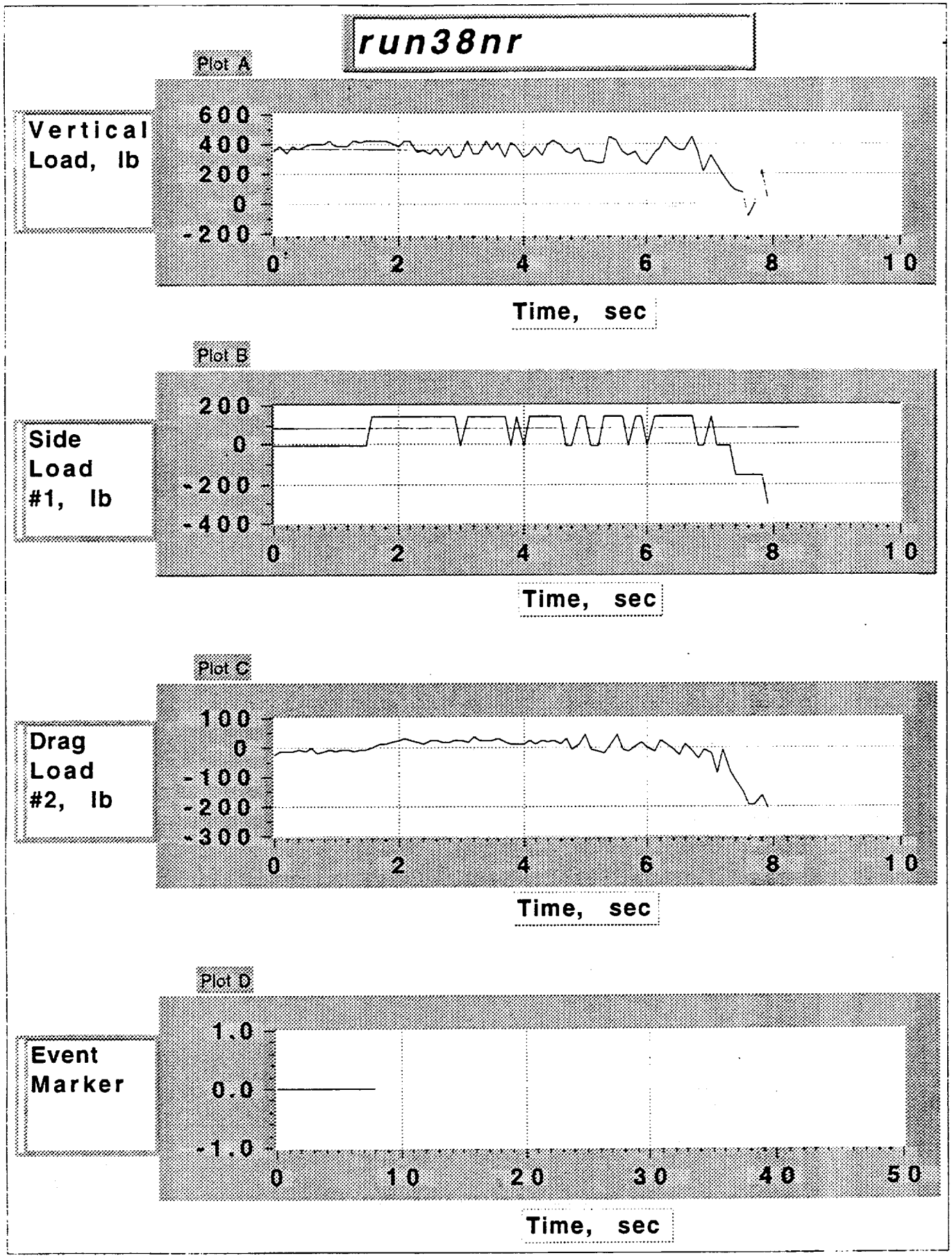

36r
Plot A
Vertical Load, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

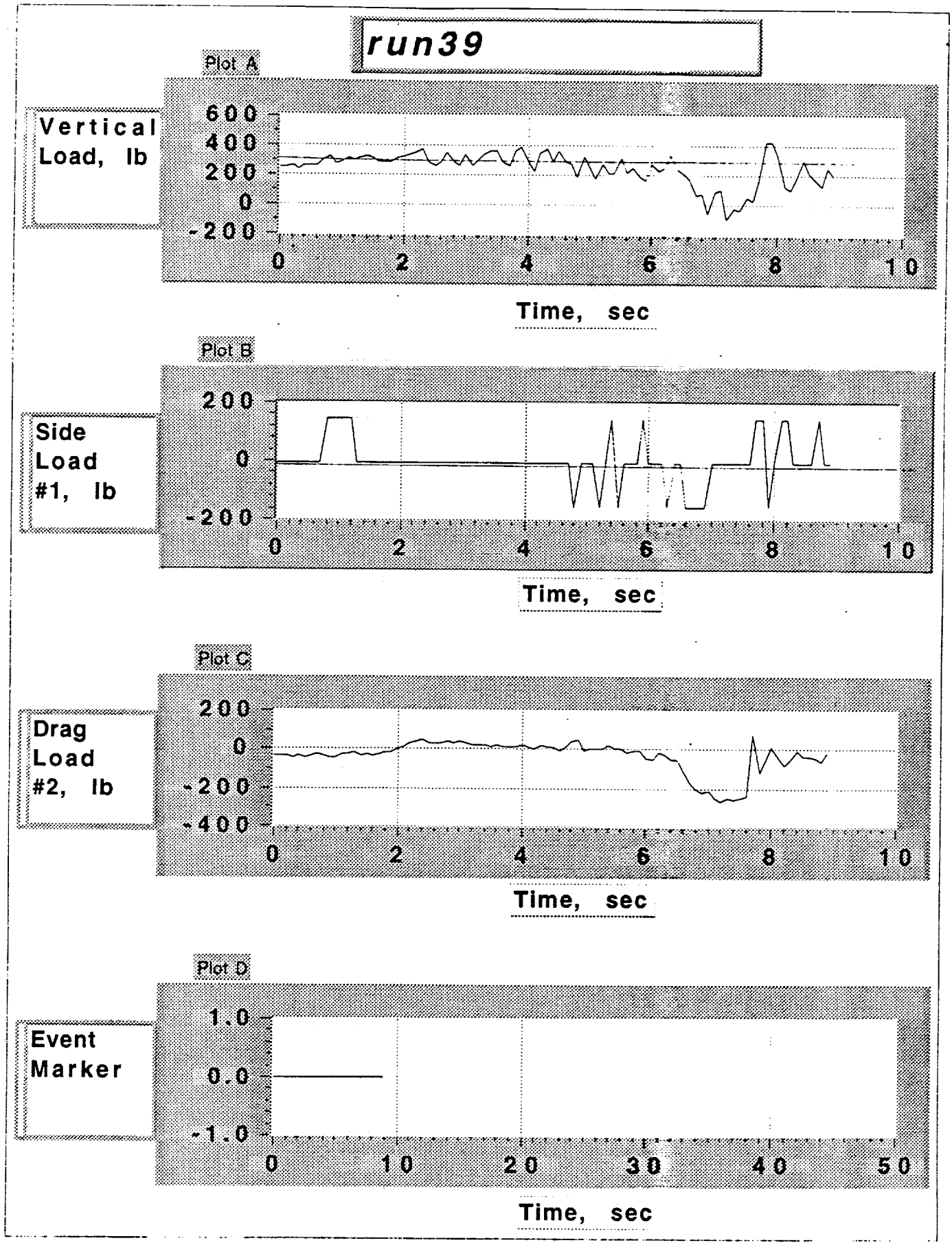

run37
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

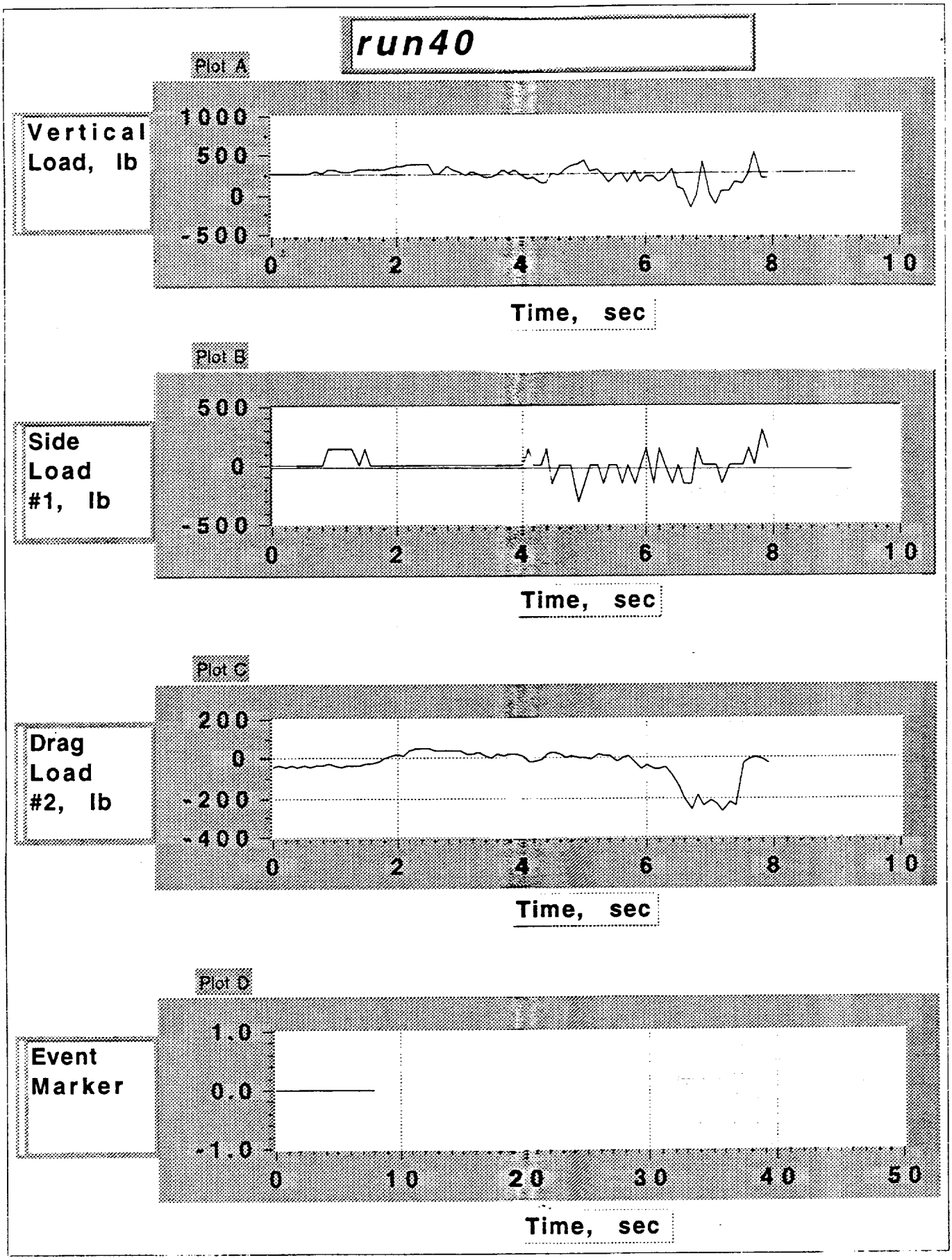

run38
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

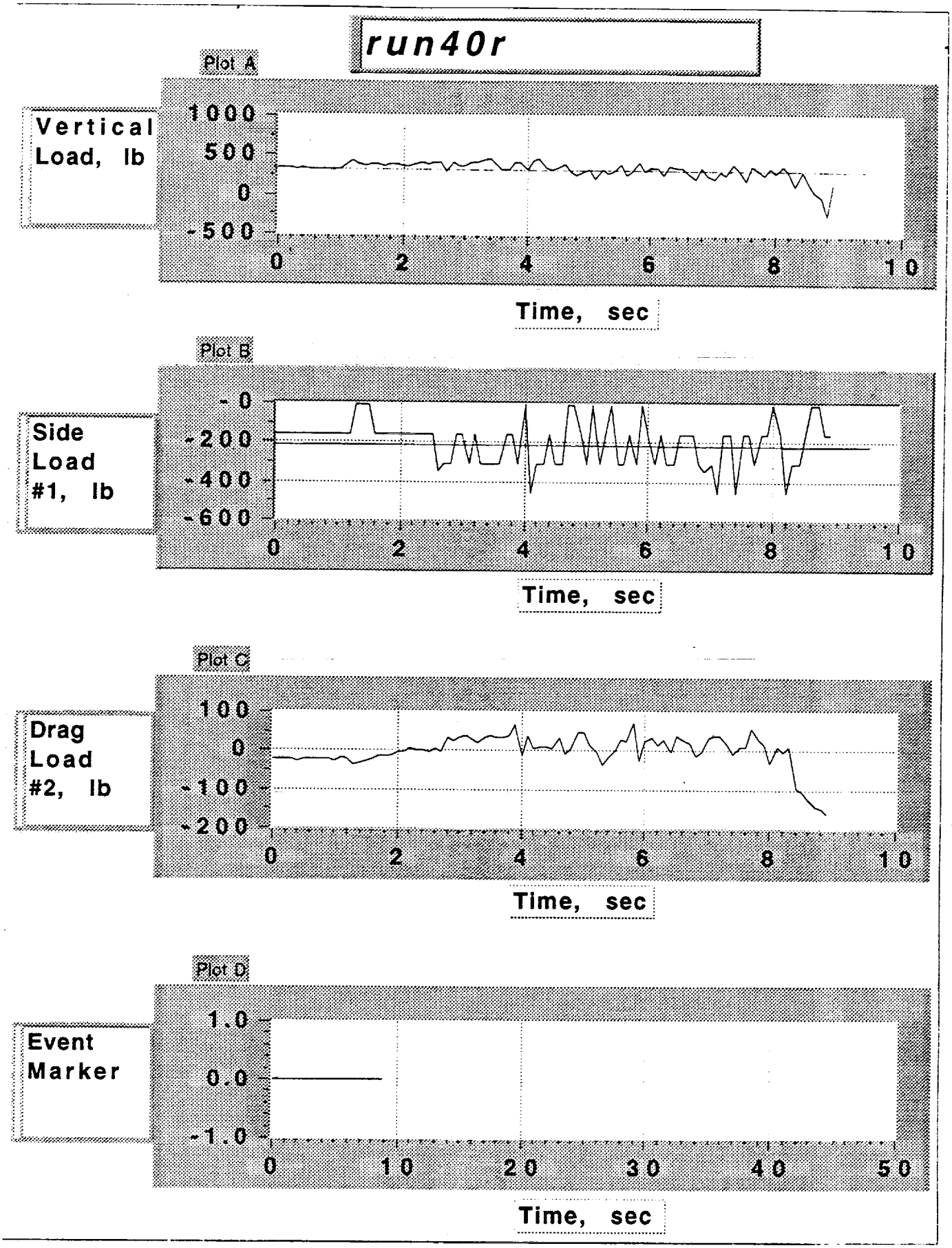

run38r
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
-600
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

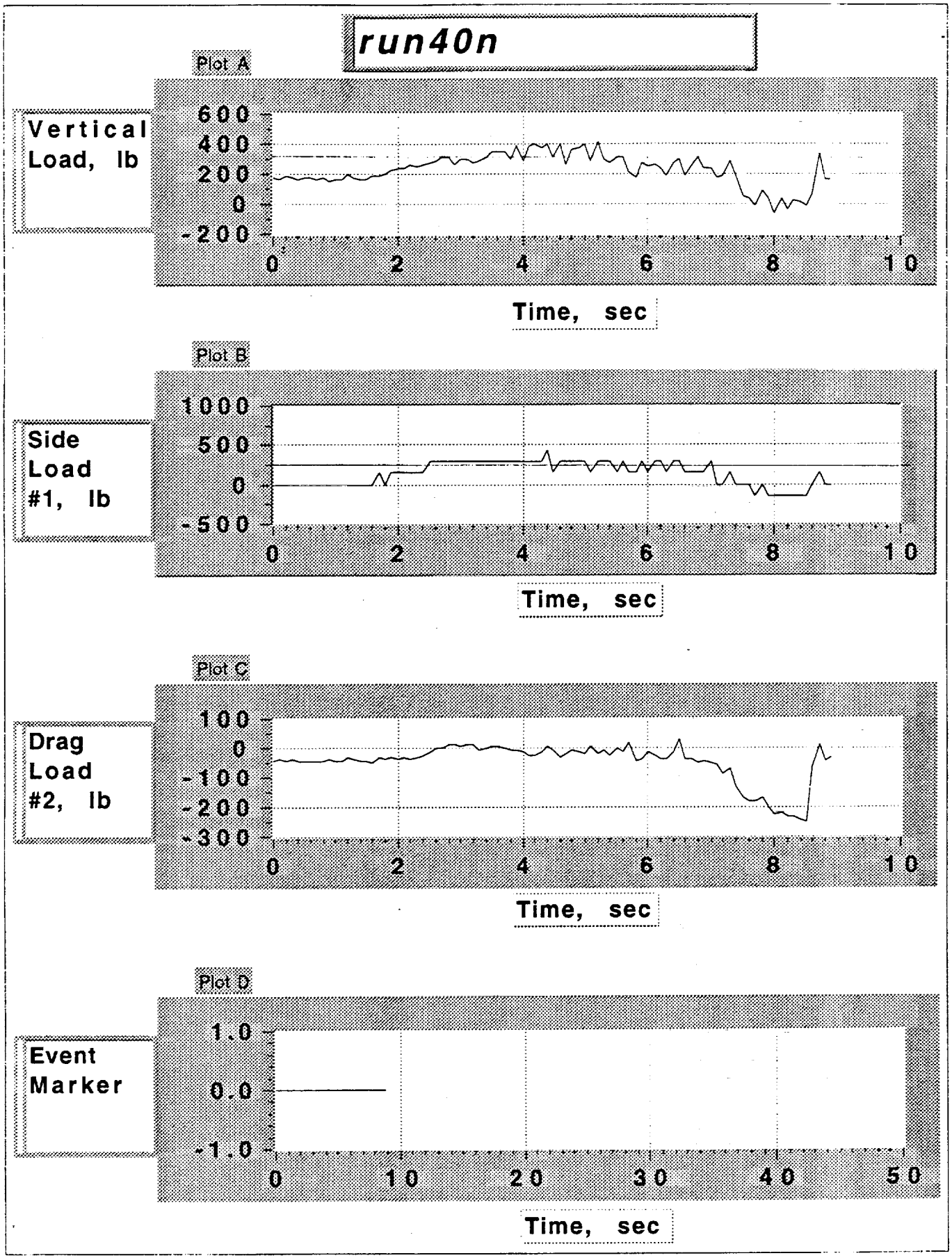

run38n
Plot A
Vertical Load, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

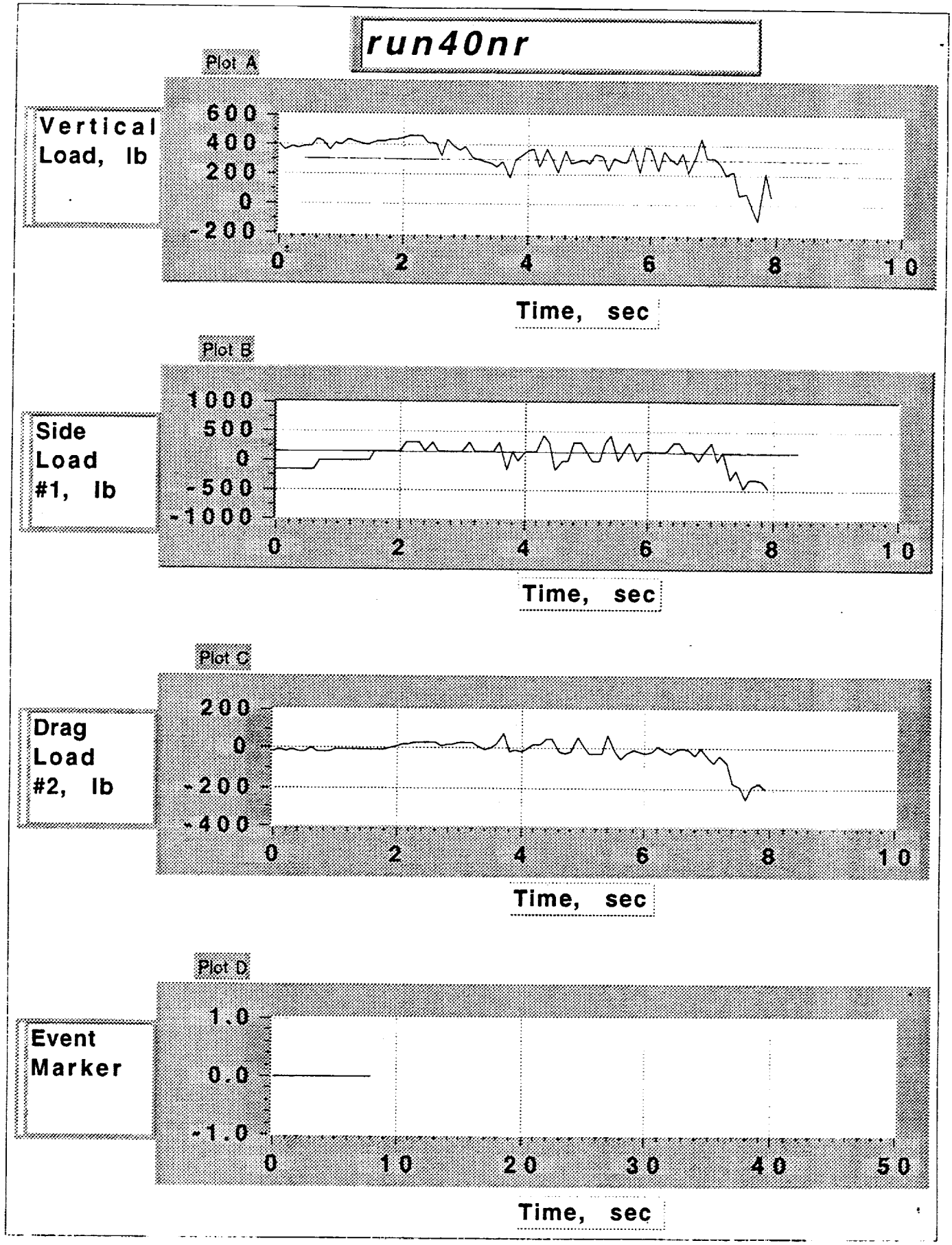

run38nr
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

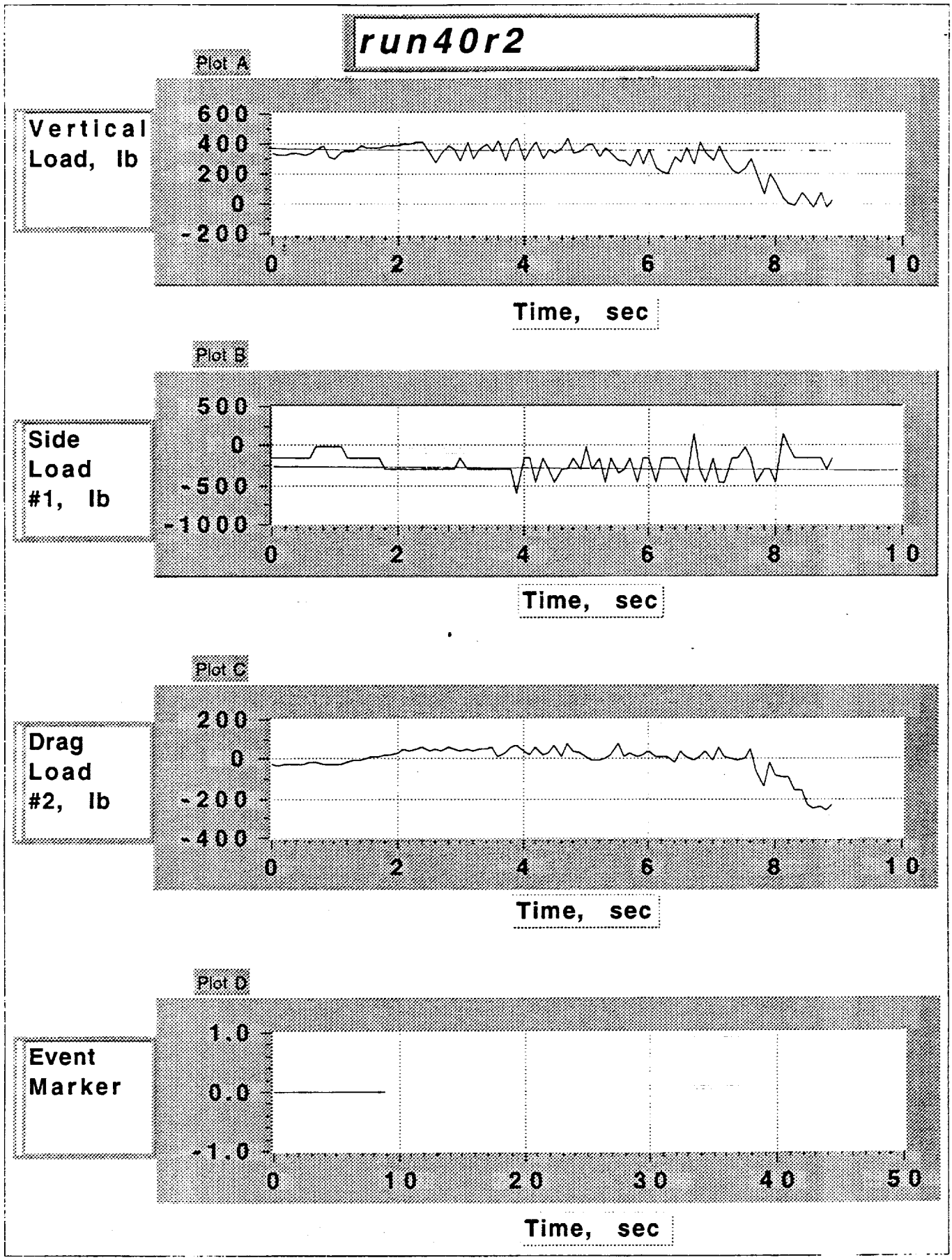

run39
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

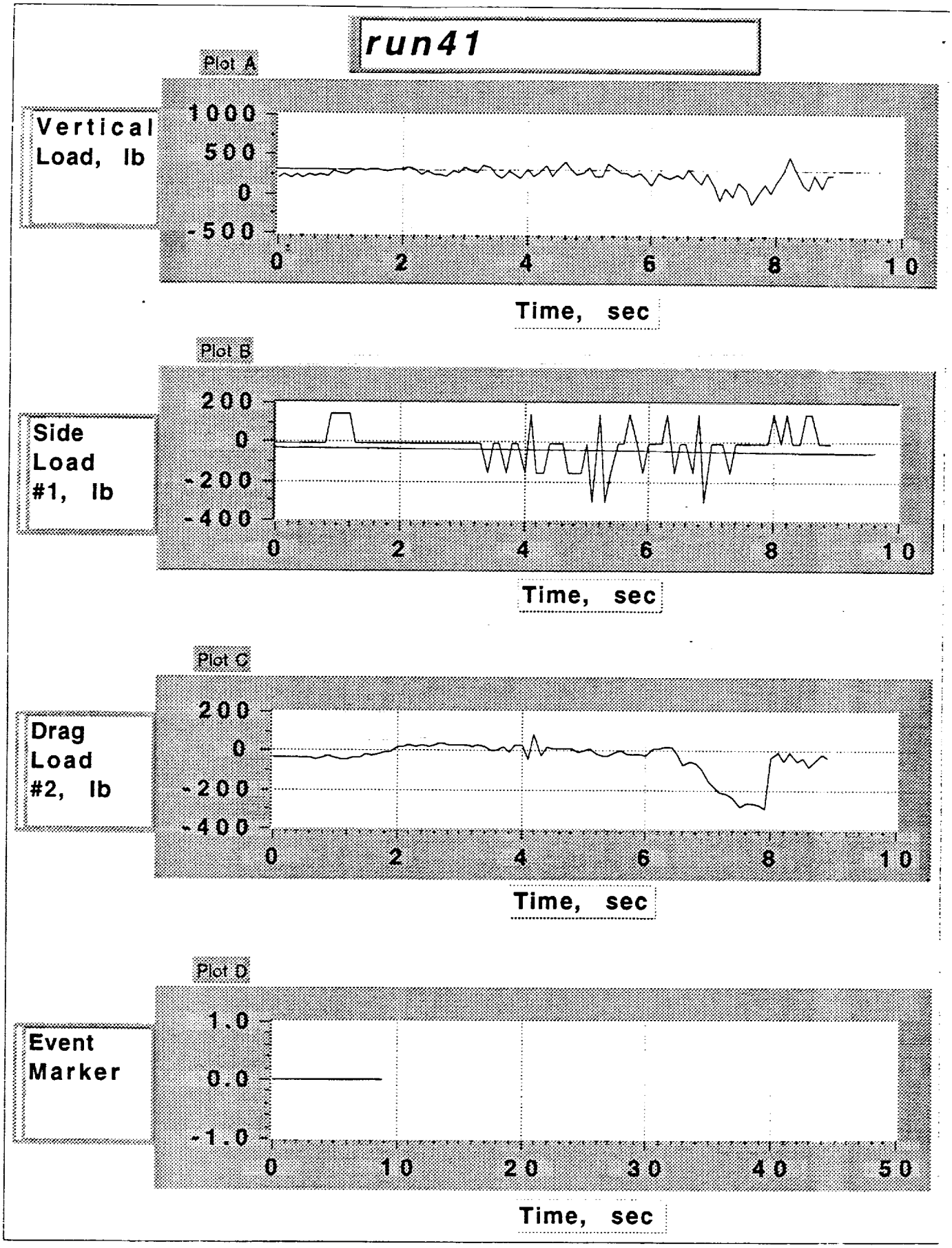

run40
Plot A
Vertical Load, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

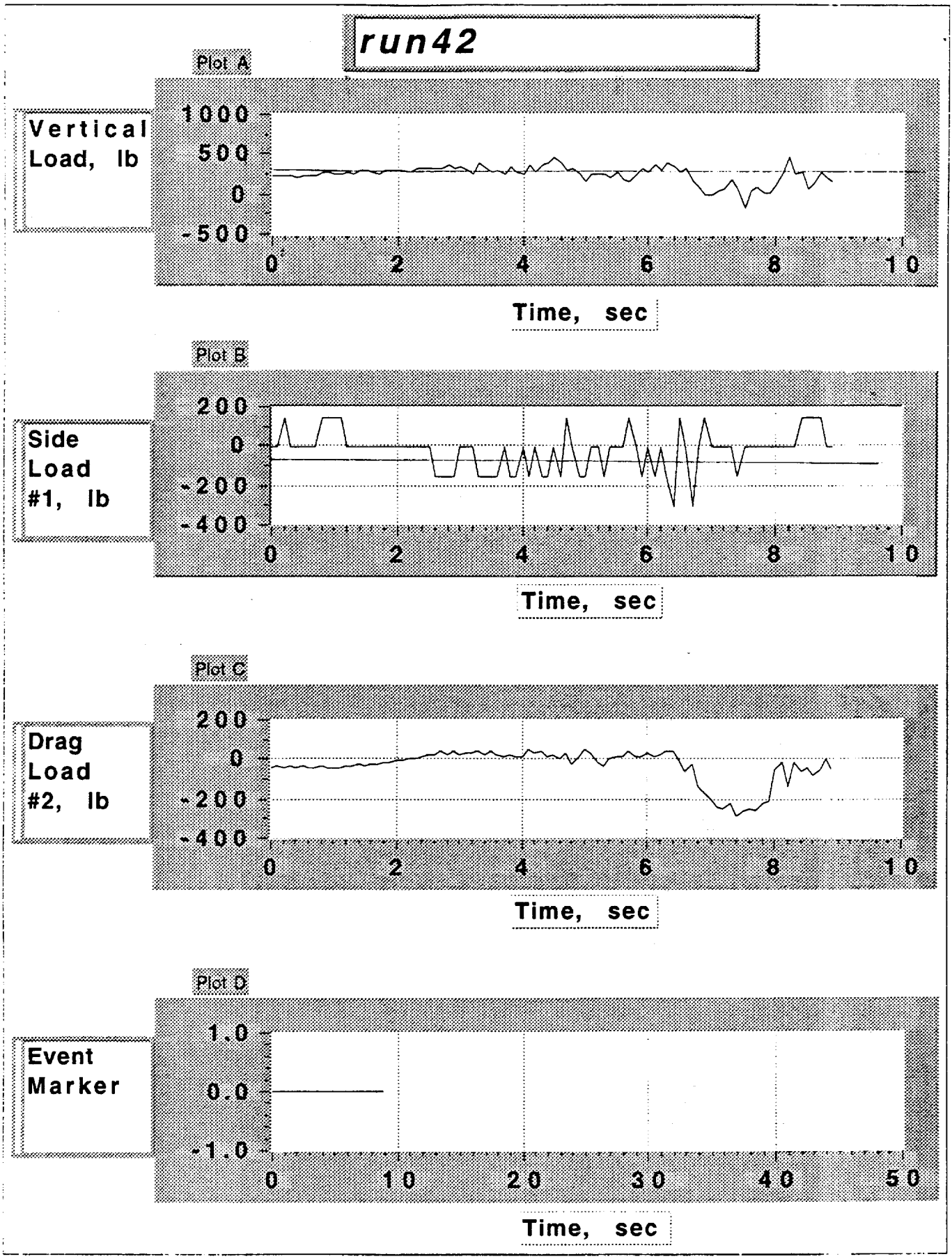

run40r
Plot A
Vertical Load, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
-600
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

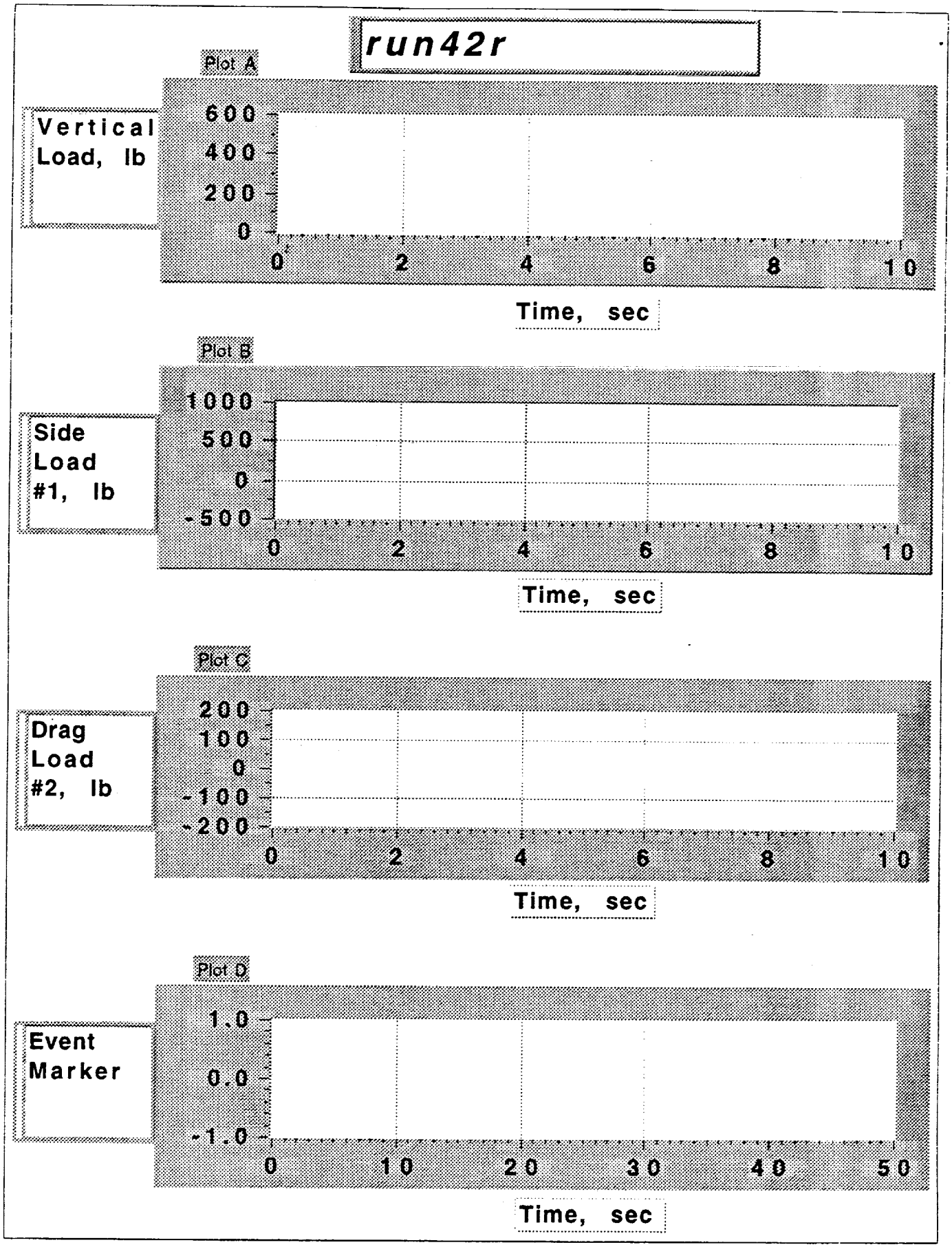

run40n
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

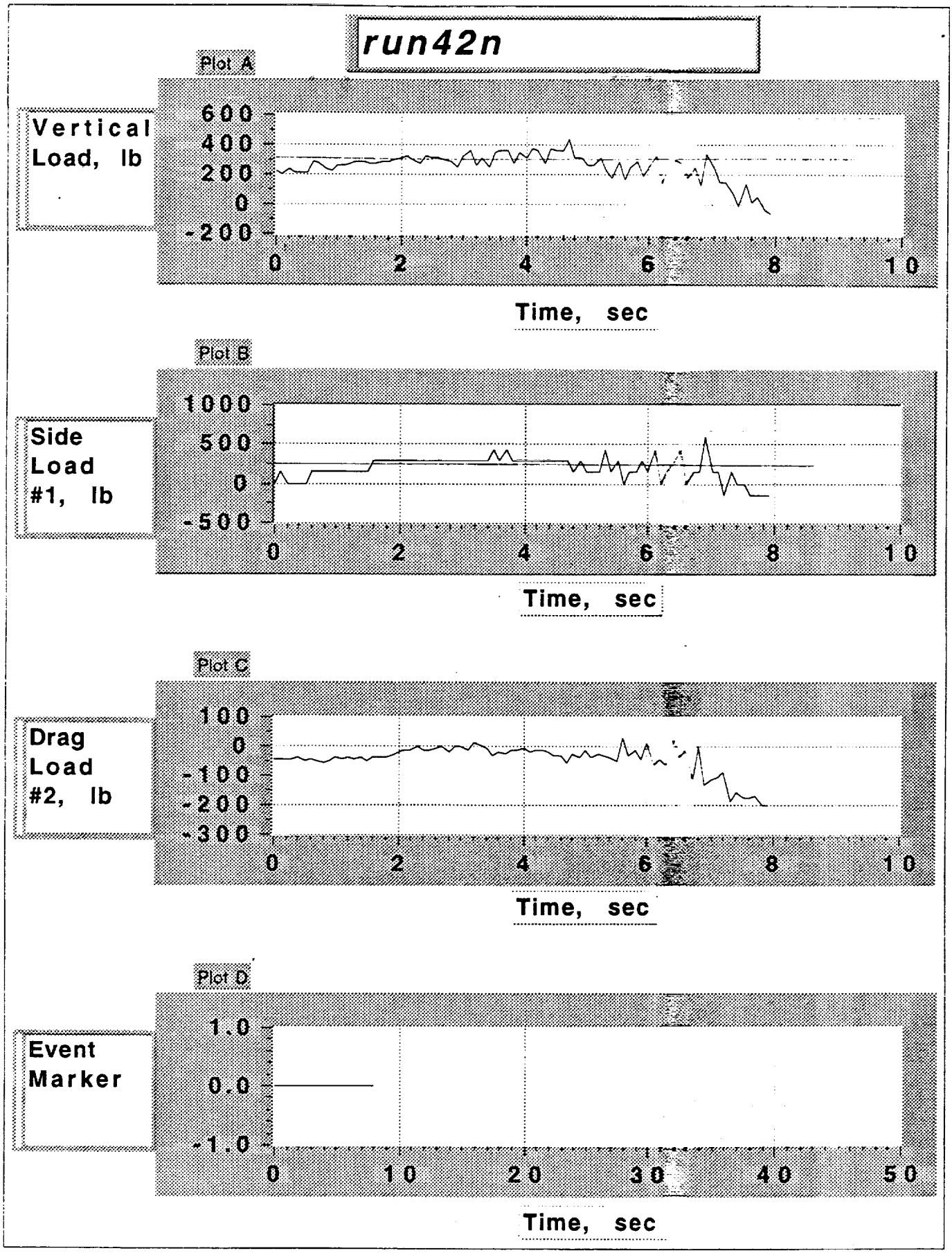

run40nr
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

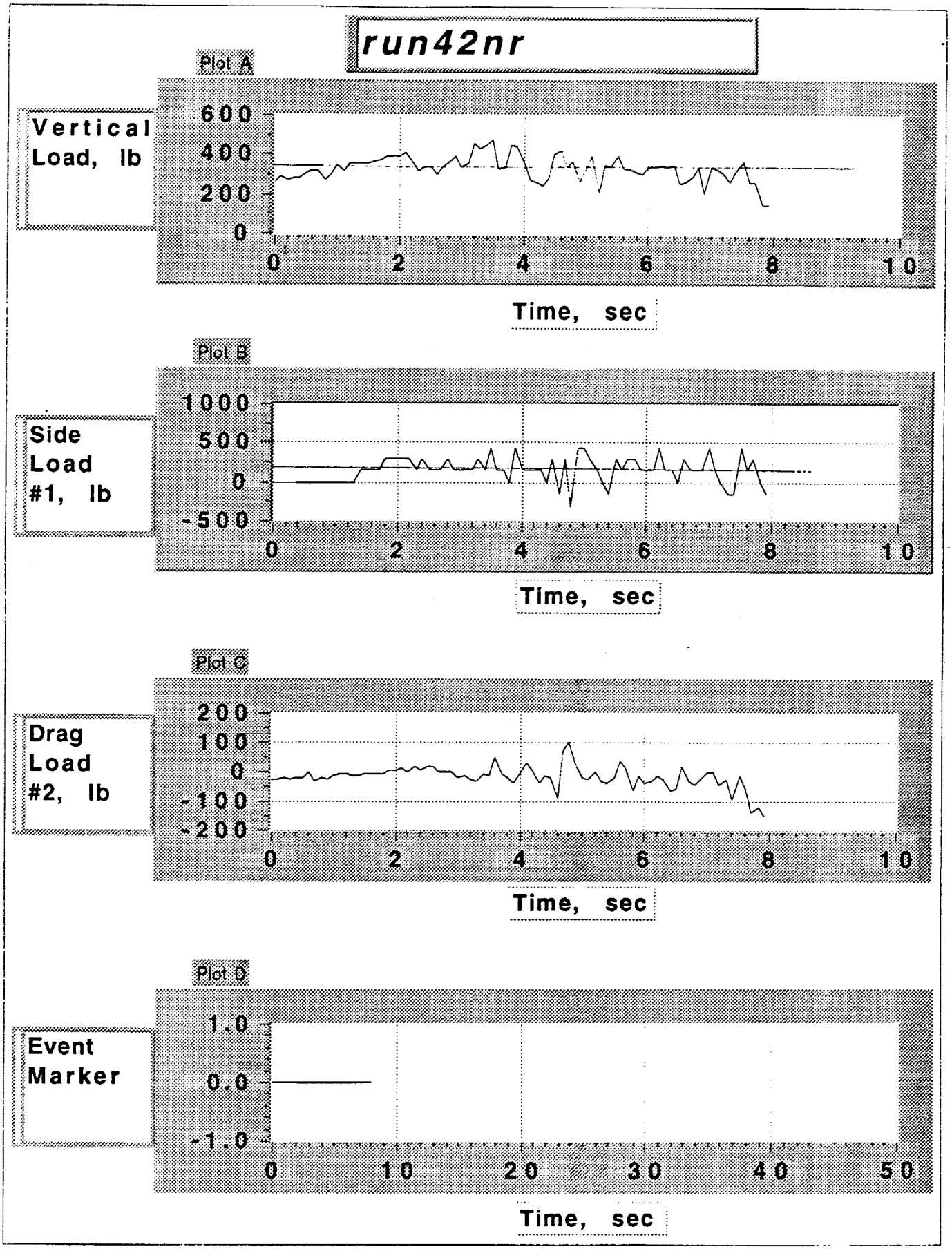

run40r2
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

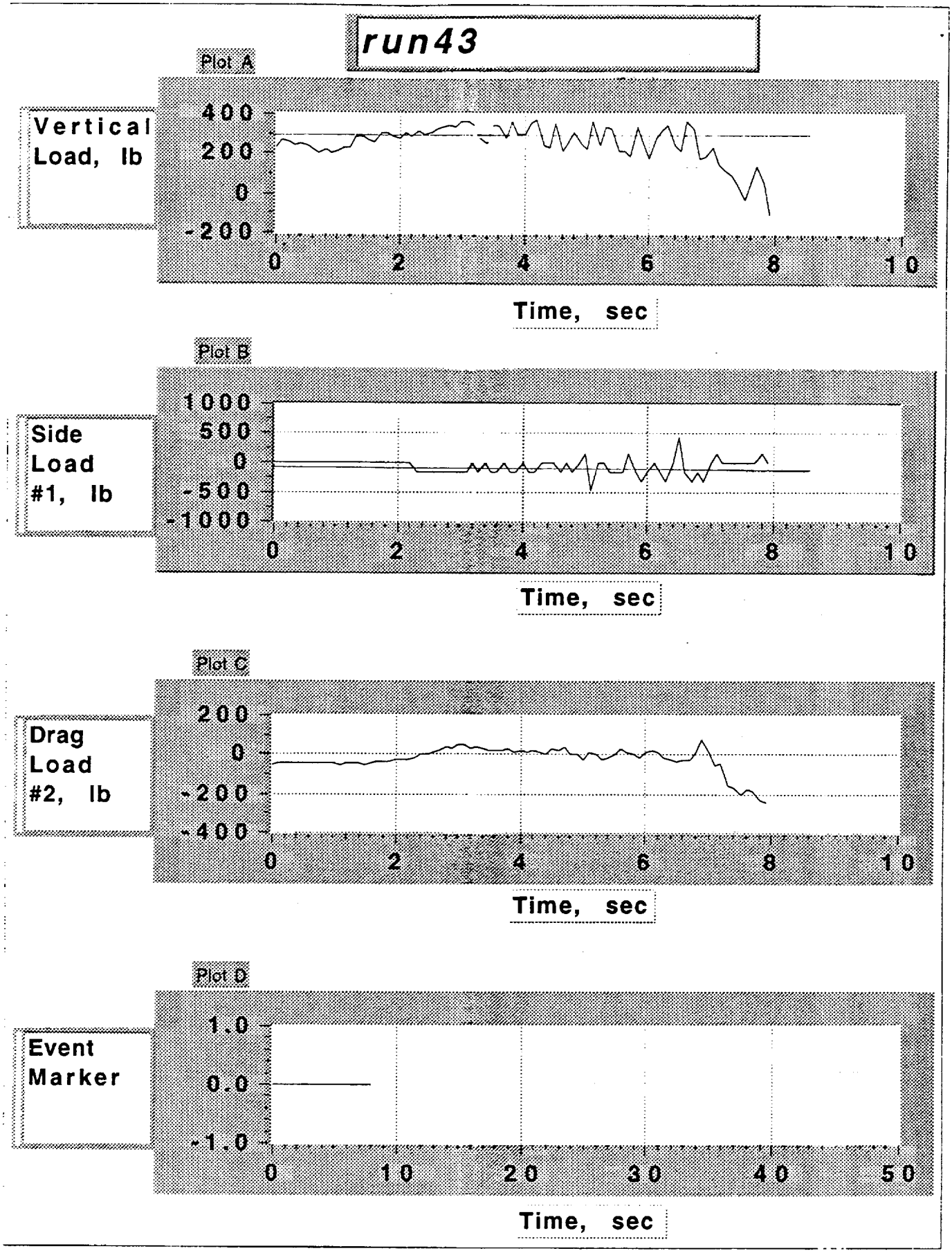

run41
Plot A
Vertical Load, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

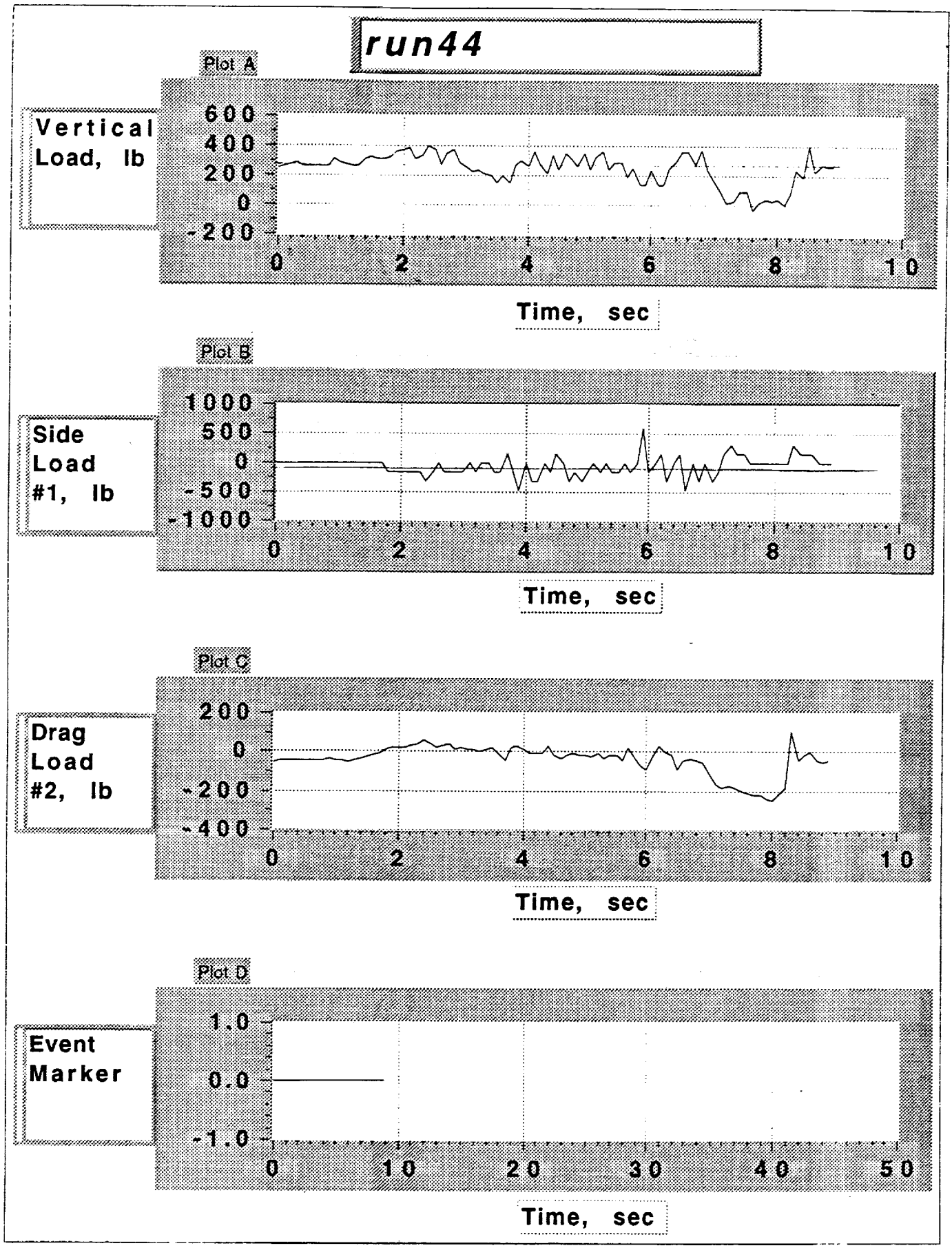

run42
Plot A
Vertical Load, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

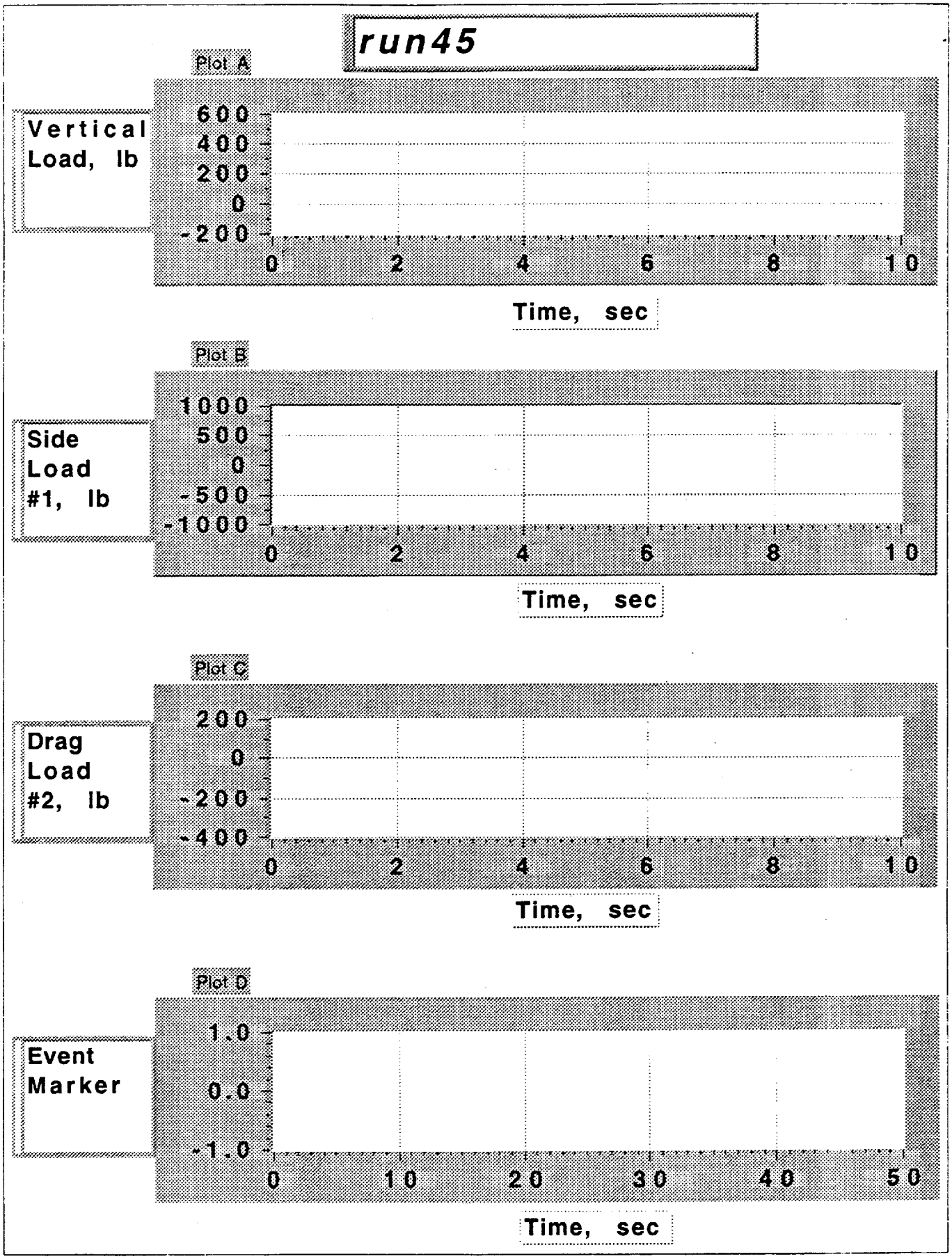

run42r
Plot A
Vertical Load, lb
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

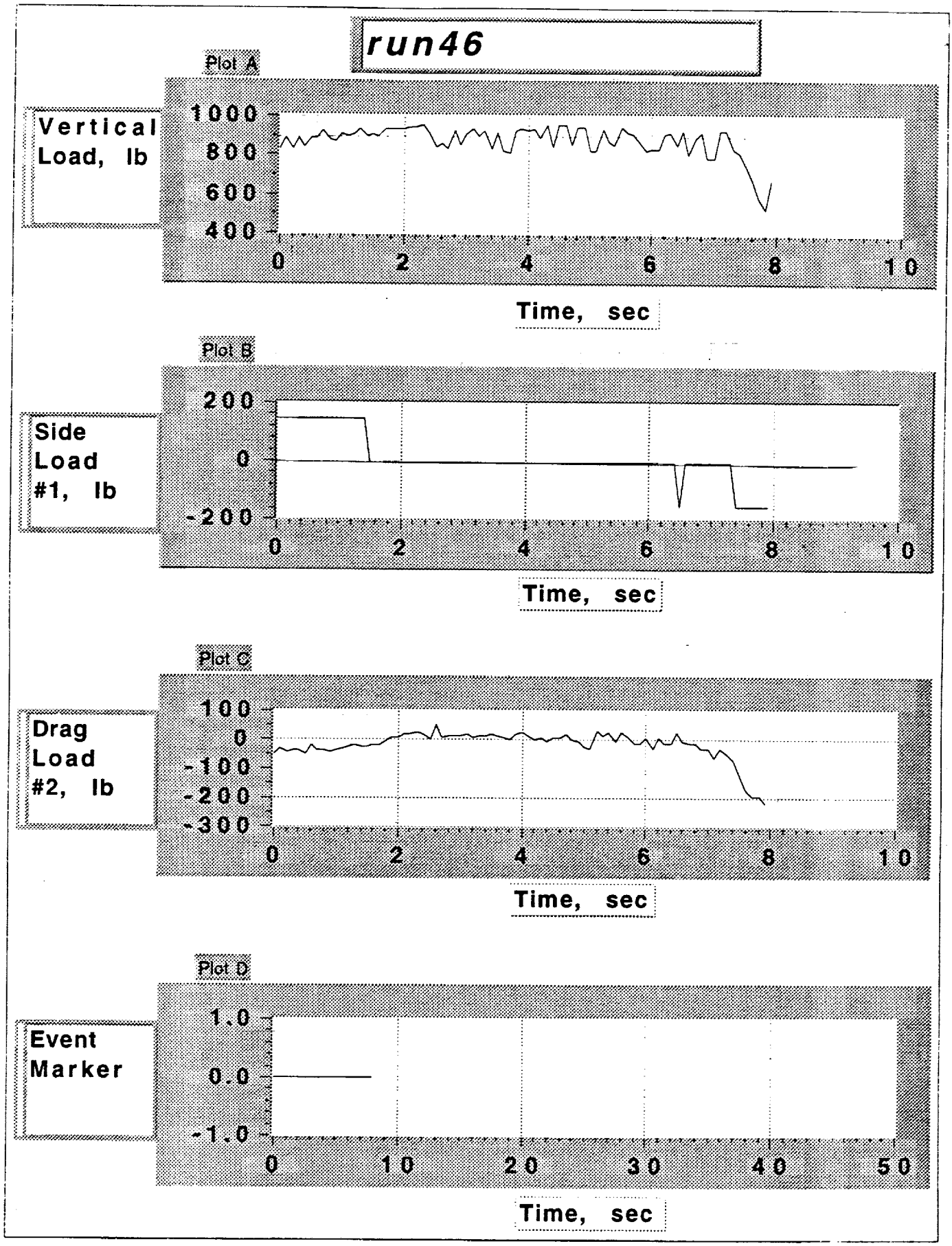

run42n
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

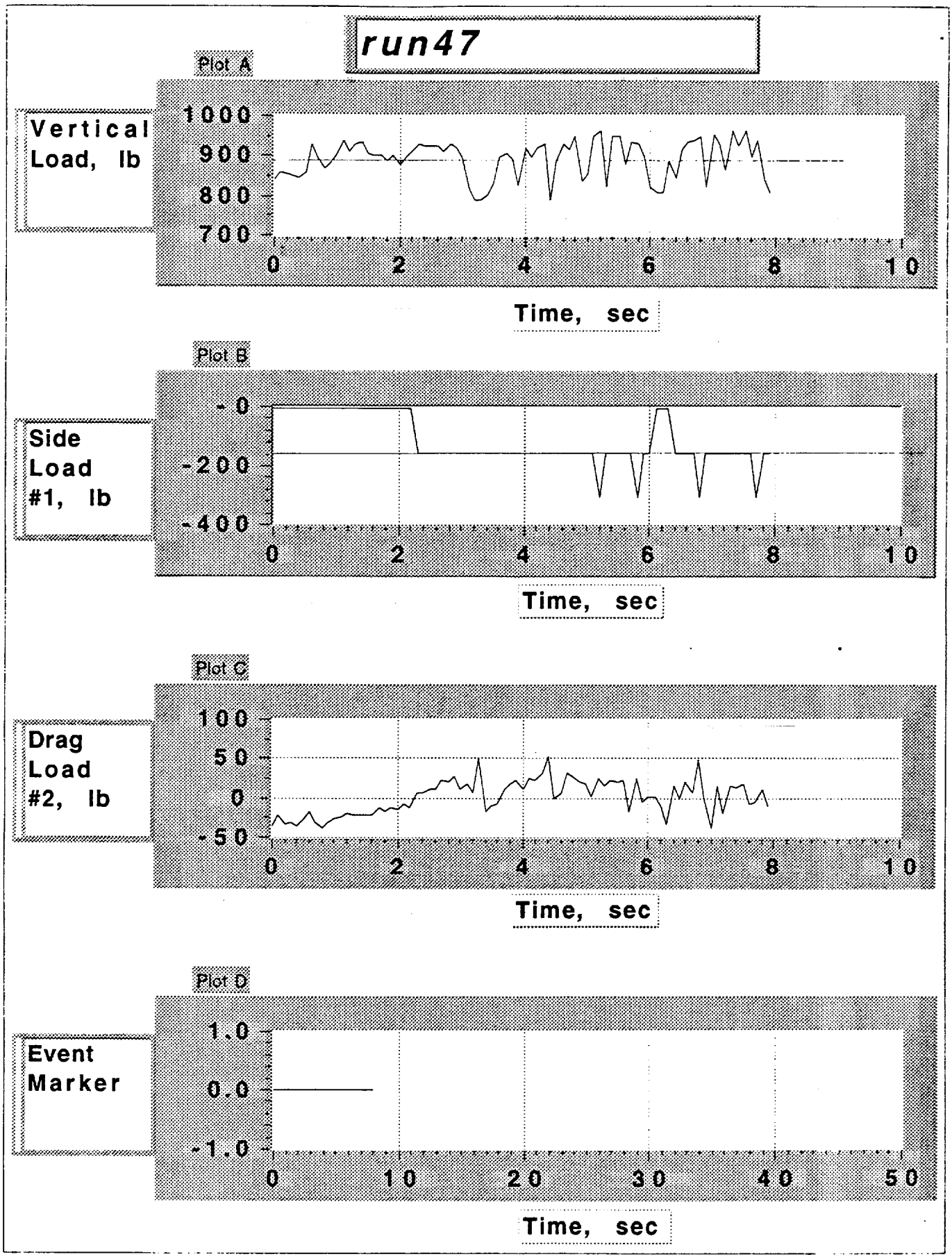

run42nr
Plot A
Vertical Load, lb
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

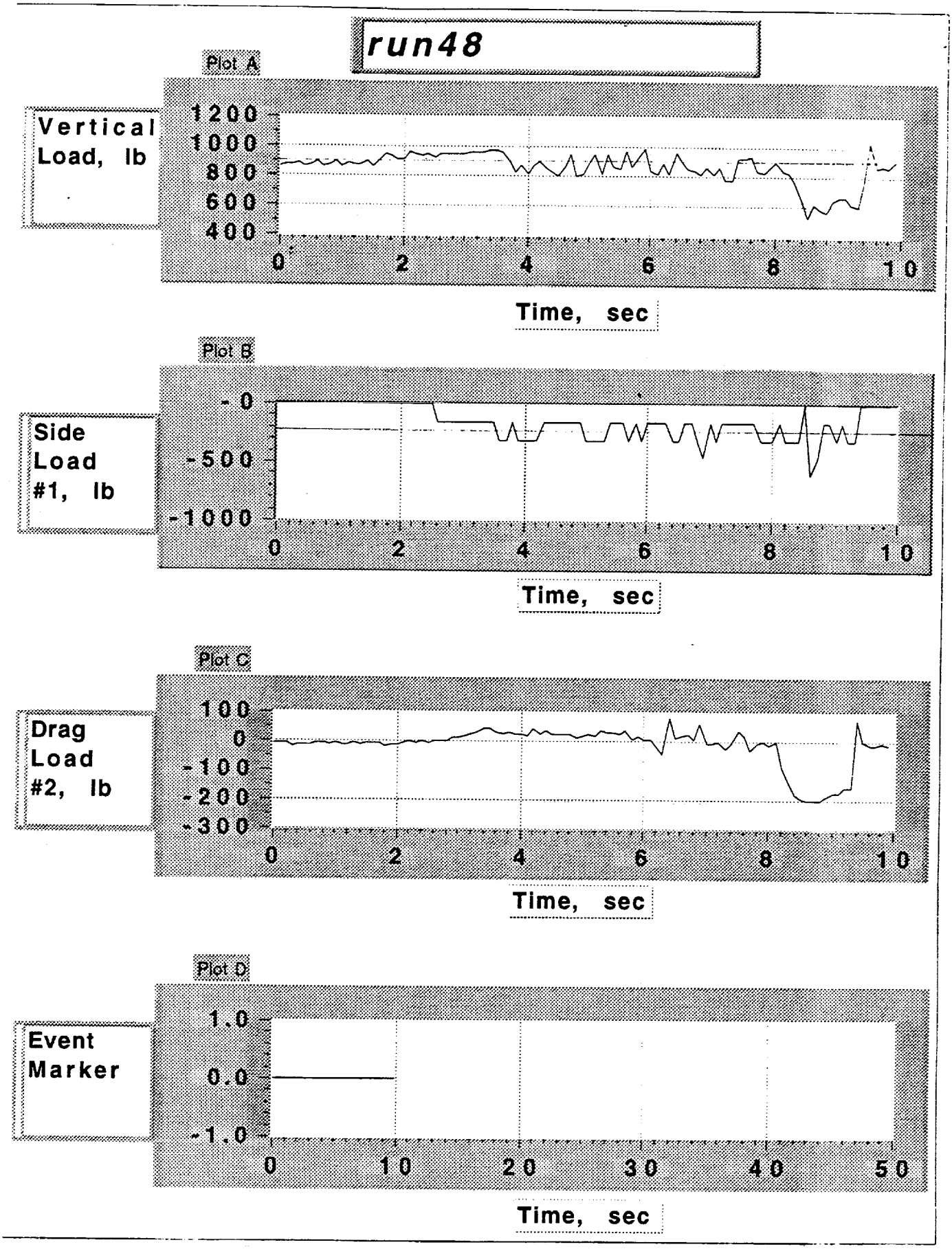

run43
Plot A
Vertical Load, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

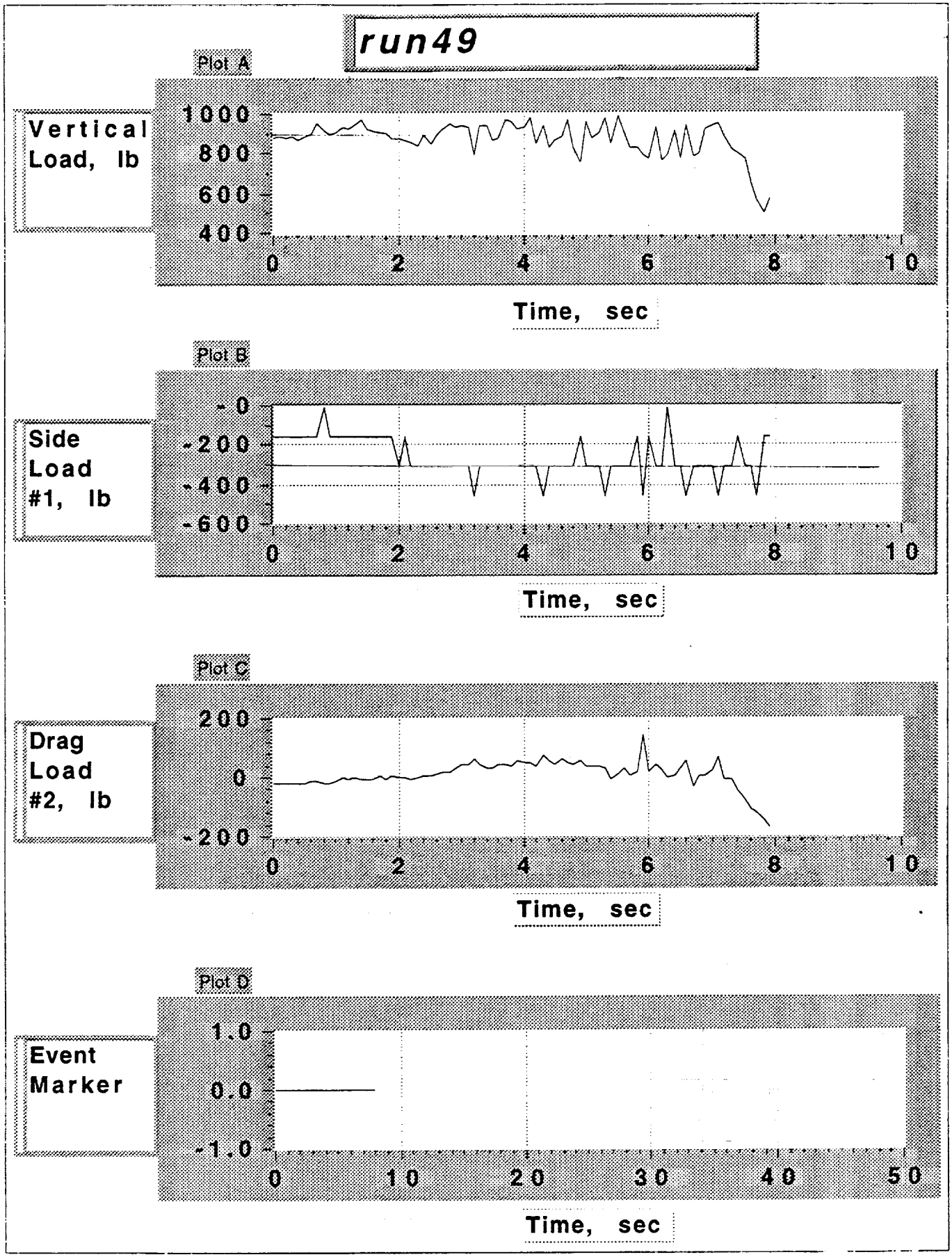

run44
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

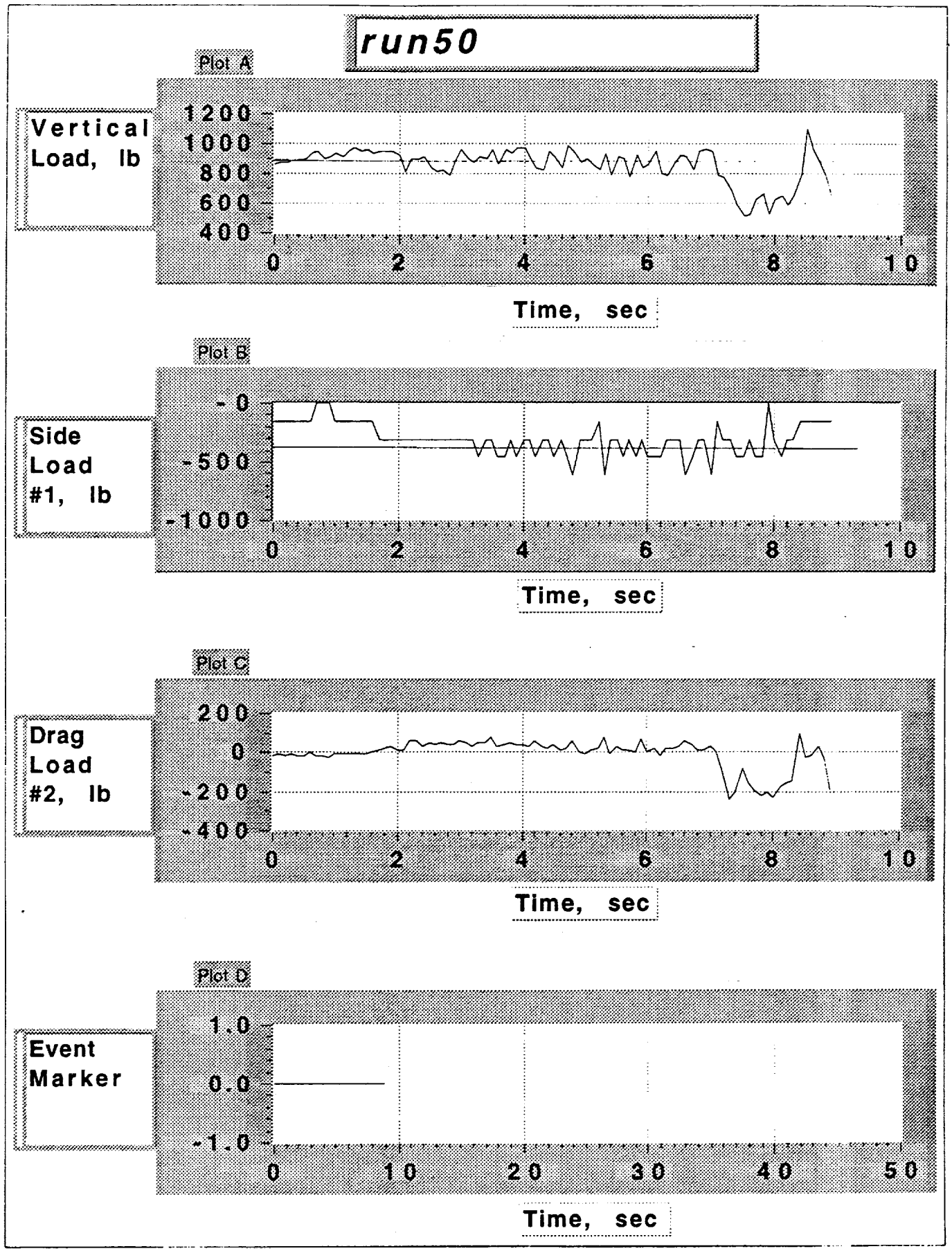

run45
Plot A
Vertical Load, lb
600
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

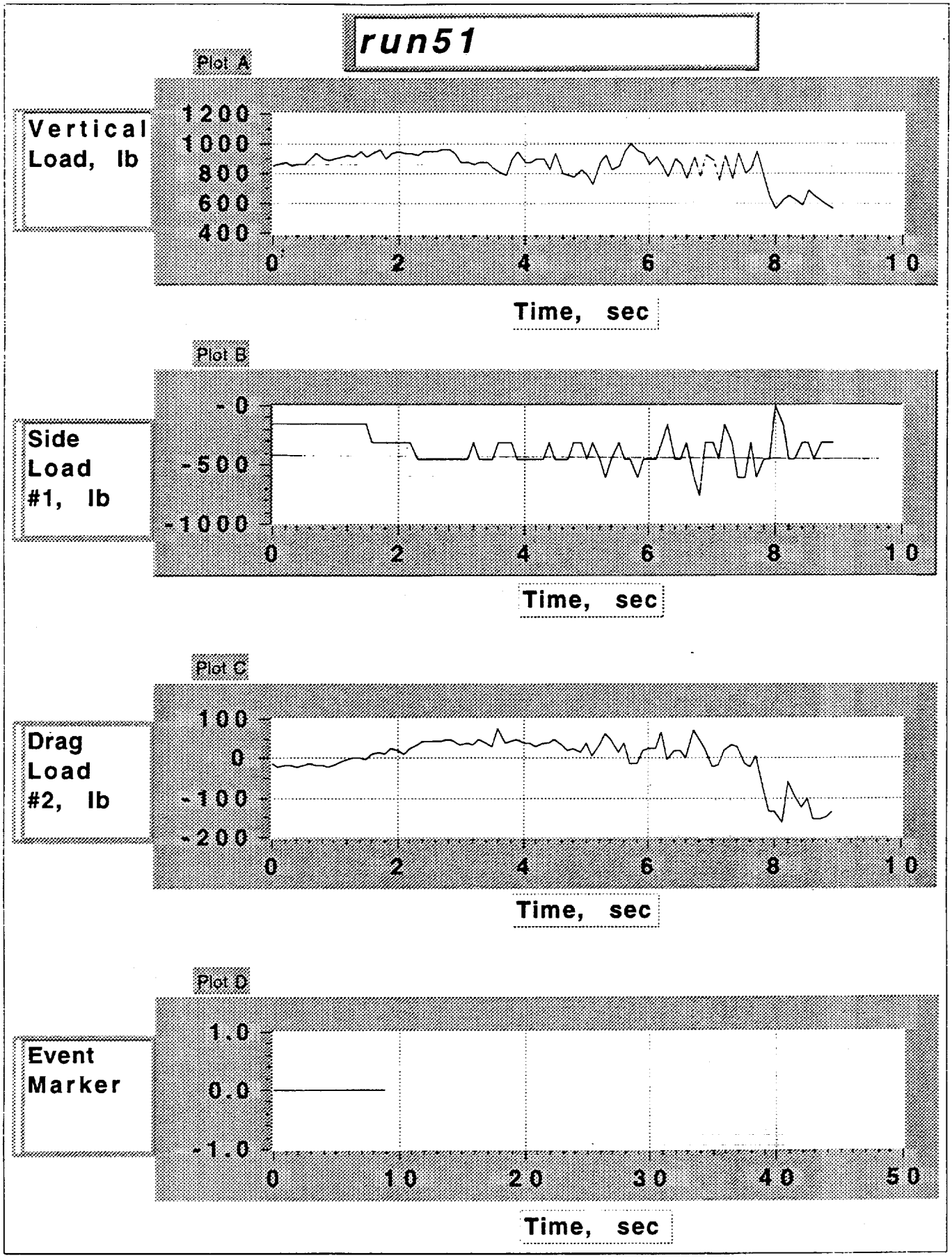

run46
Plot A
Vertical Load, lb
1000
800
600
400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

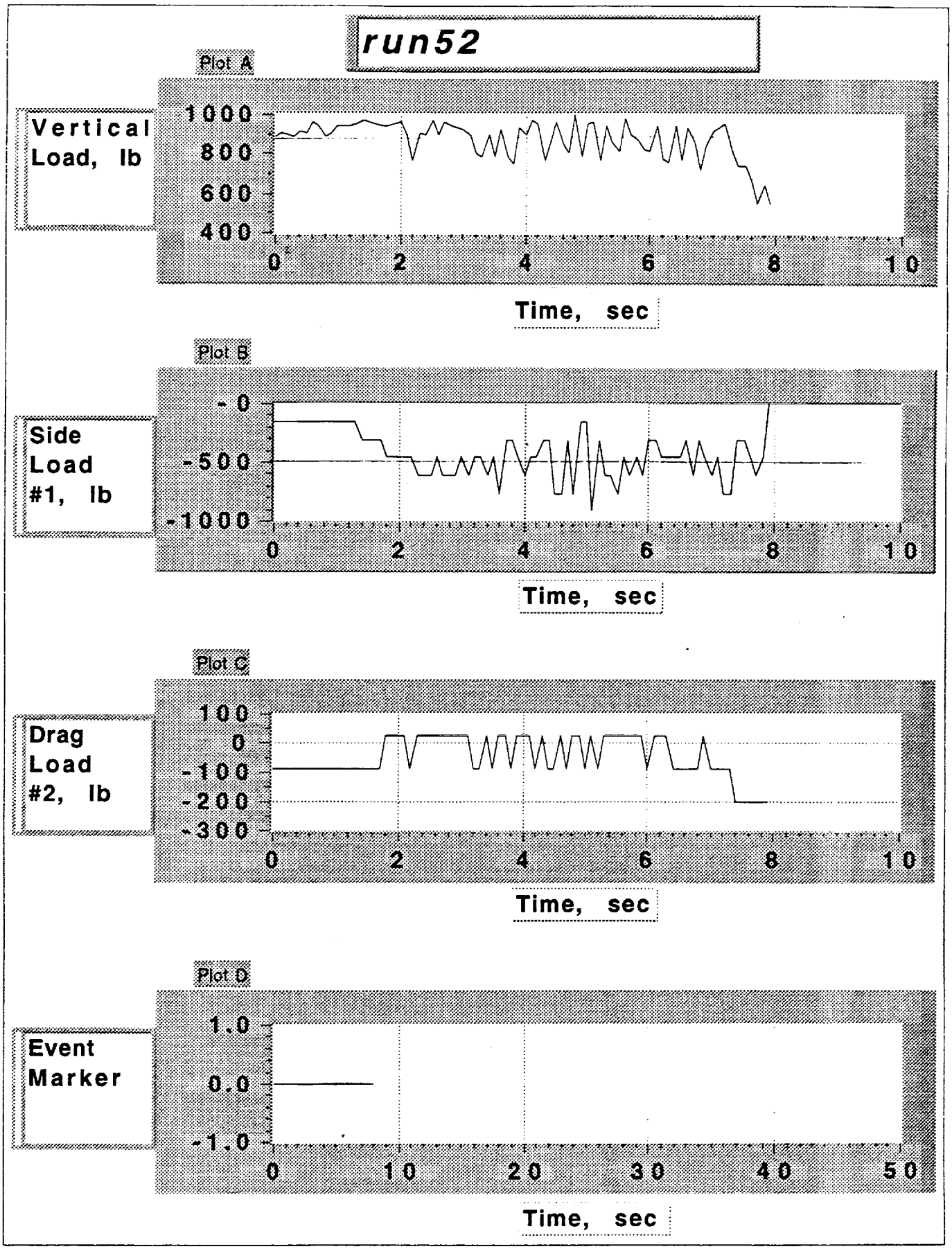

run47
Plot A
Vertical Load, lb
1000
900
800
700
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
50
0
-50
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

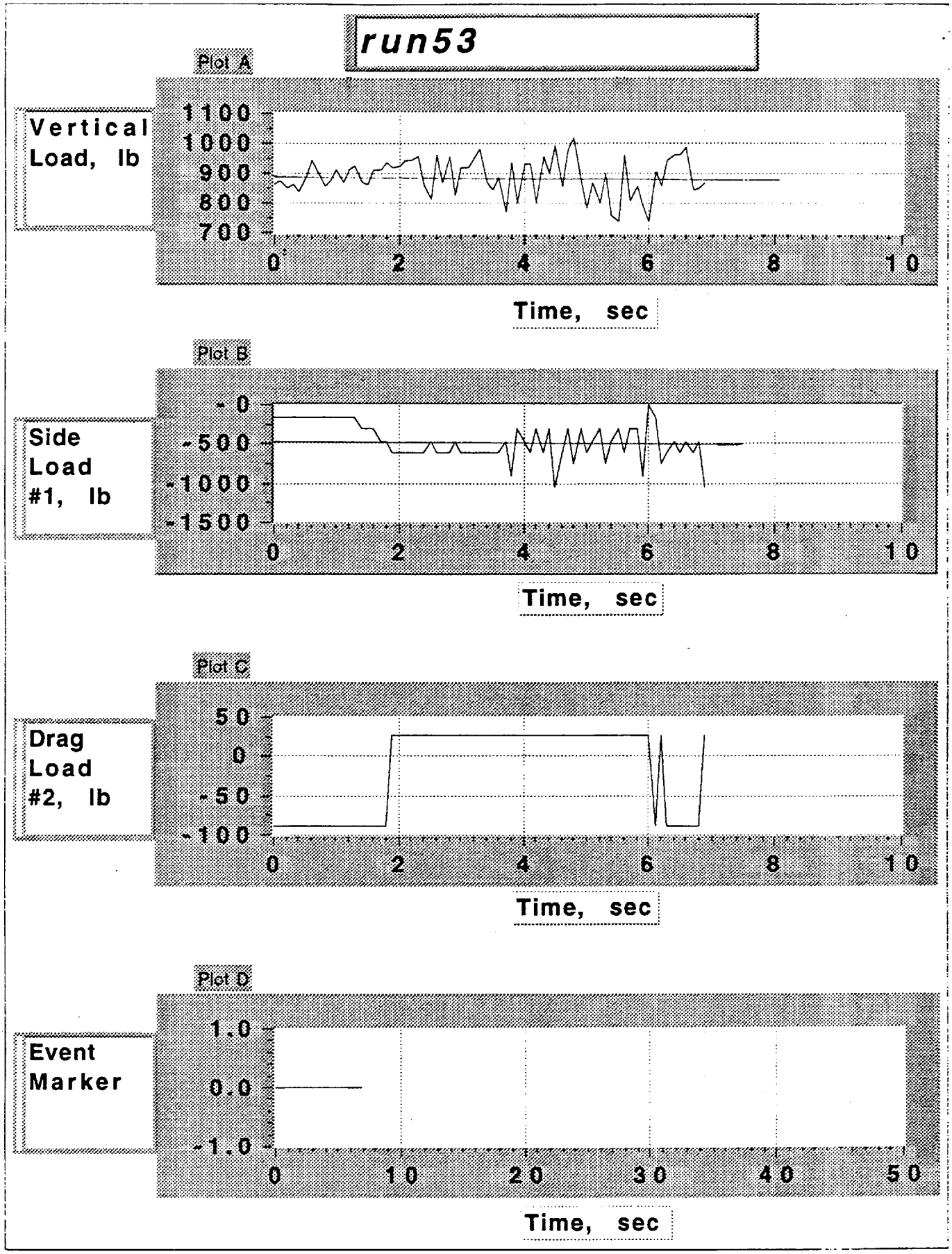

run48
Plot A
Vertical Load, lb
1200
1000
800
600
400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

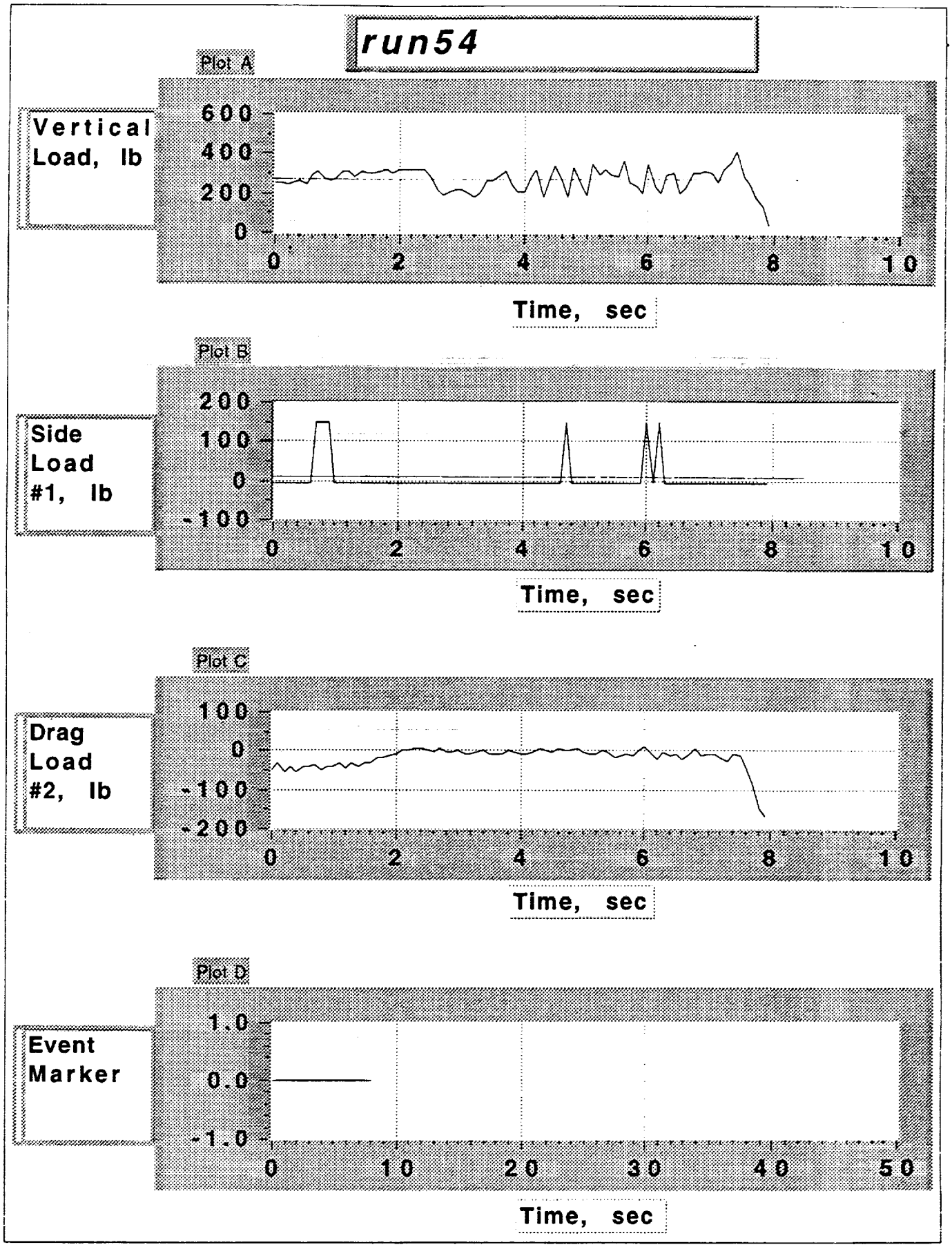

run49
Plot A
Vertical Load, lb
1000
800
600
400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
-600
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

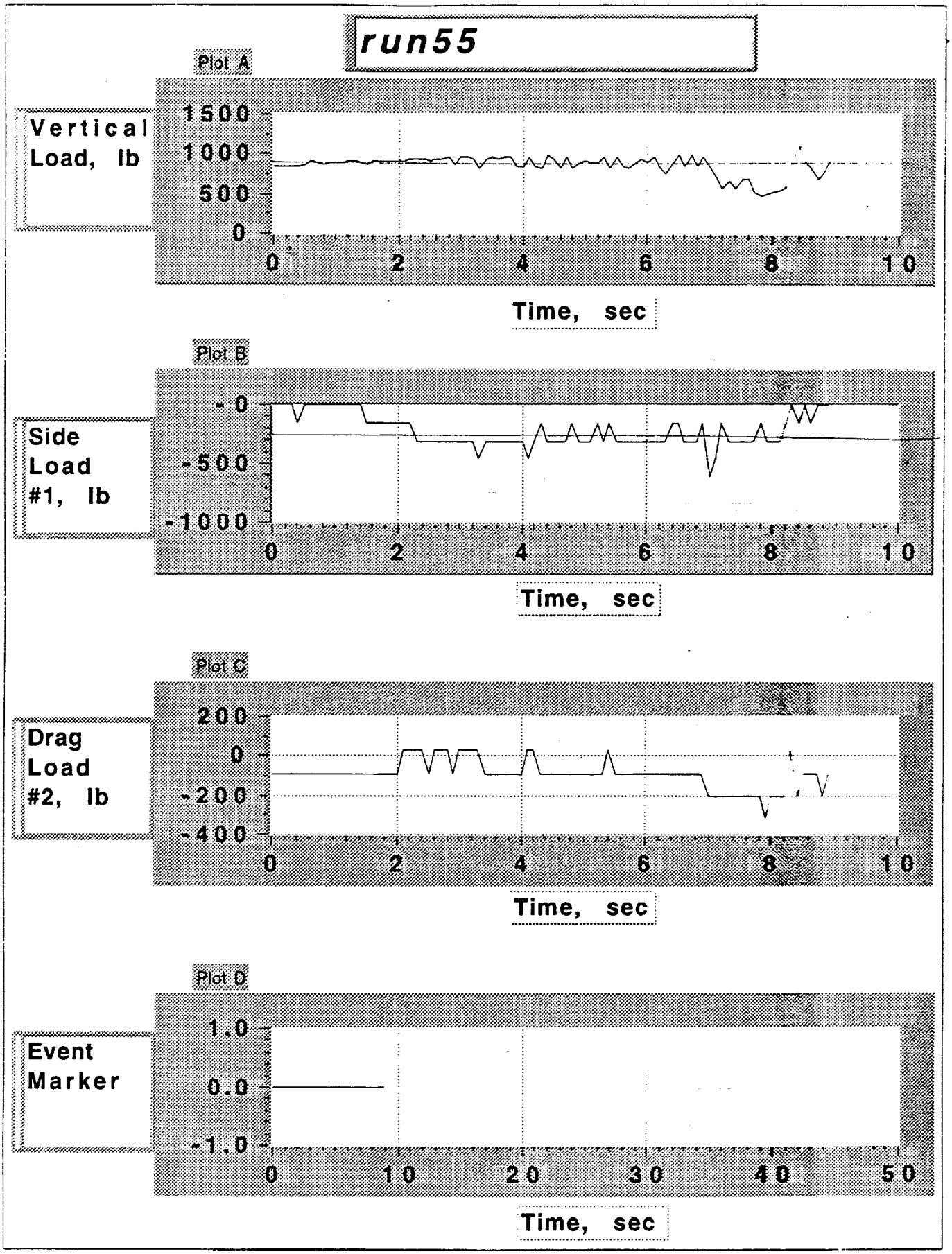

run50
Plot A
Vertical Load, lb
1200
1000
800
600
400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

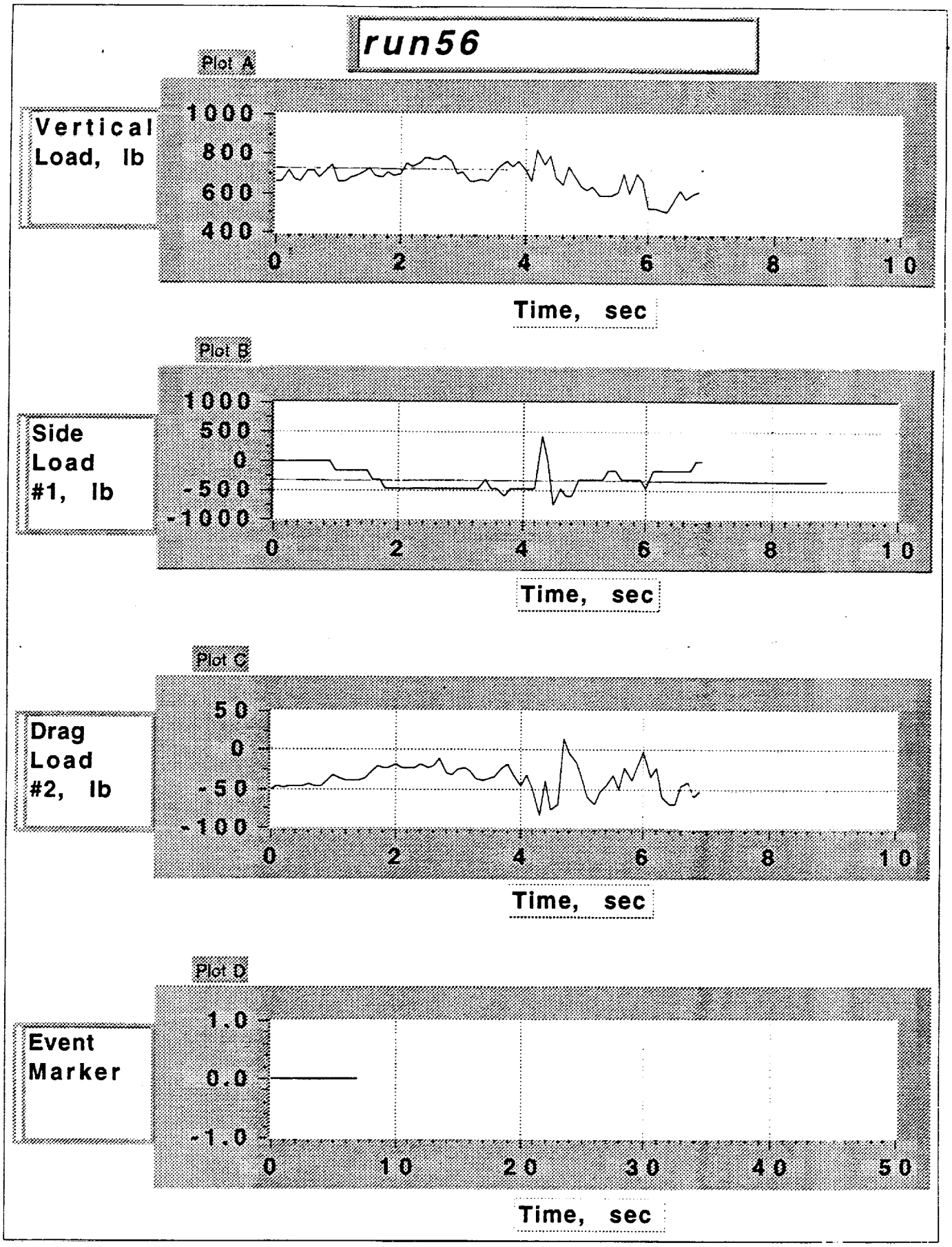

run51
Plot A
Vertical Load, lb
1200
1000
800
600
400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

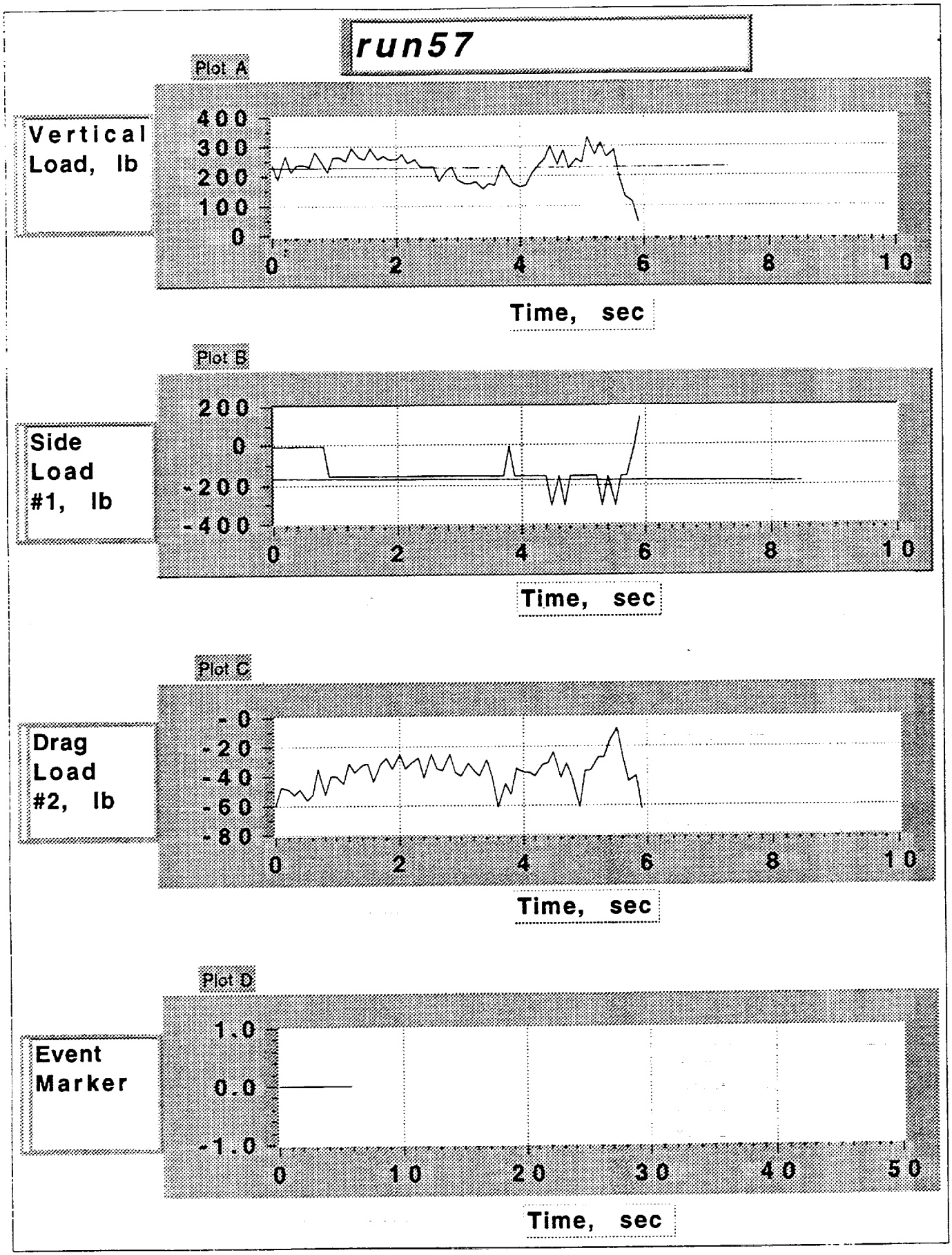

run52
Plot A
Vertical Load, lb
1000
800
600
400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
- 0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

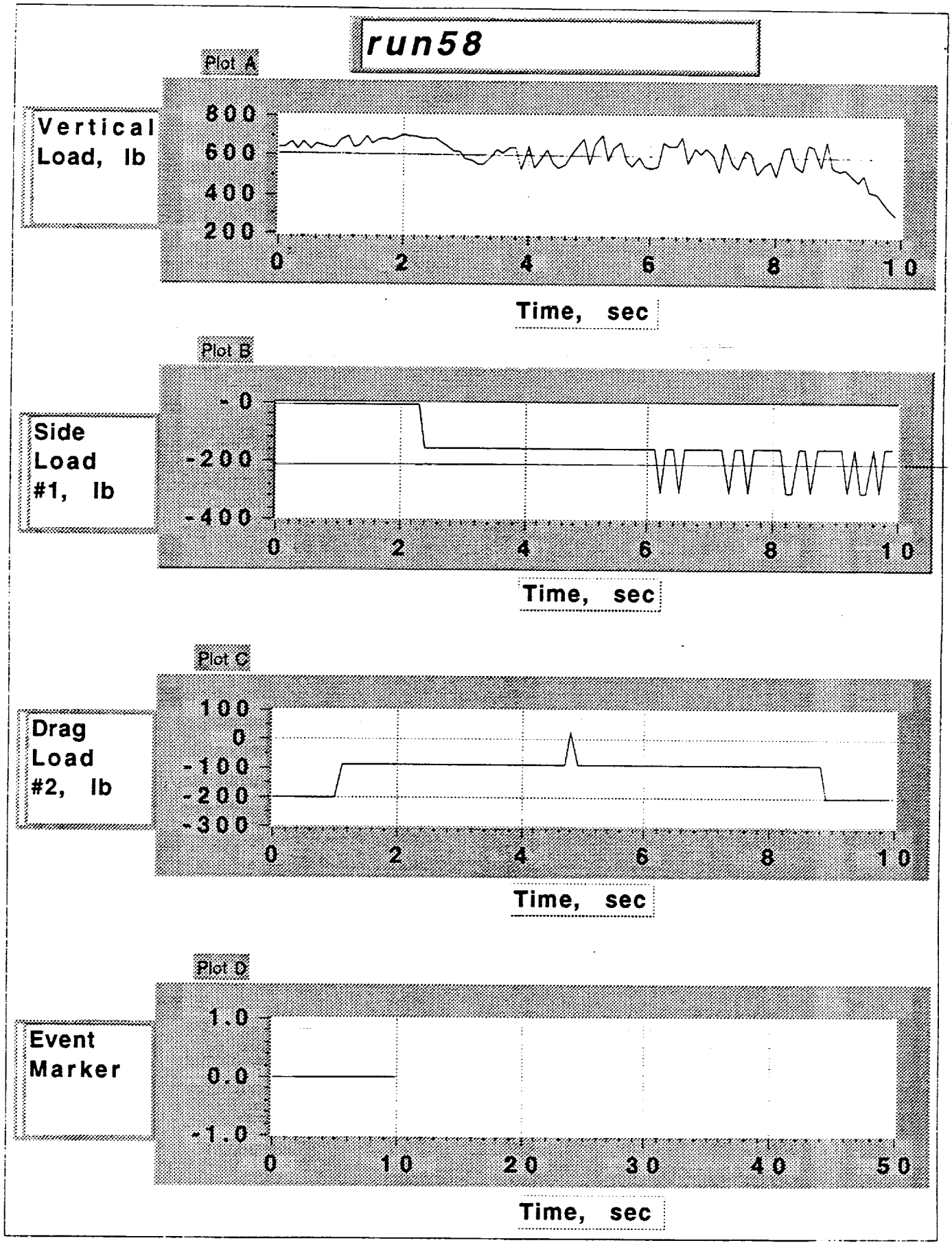

run53
Plot A
Vertical Load, lb
1100
1000
900
800
700
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-500
-1000
-1500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
50
0
-50
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

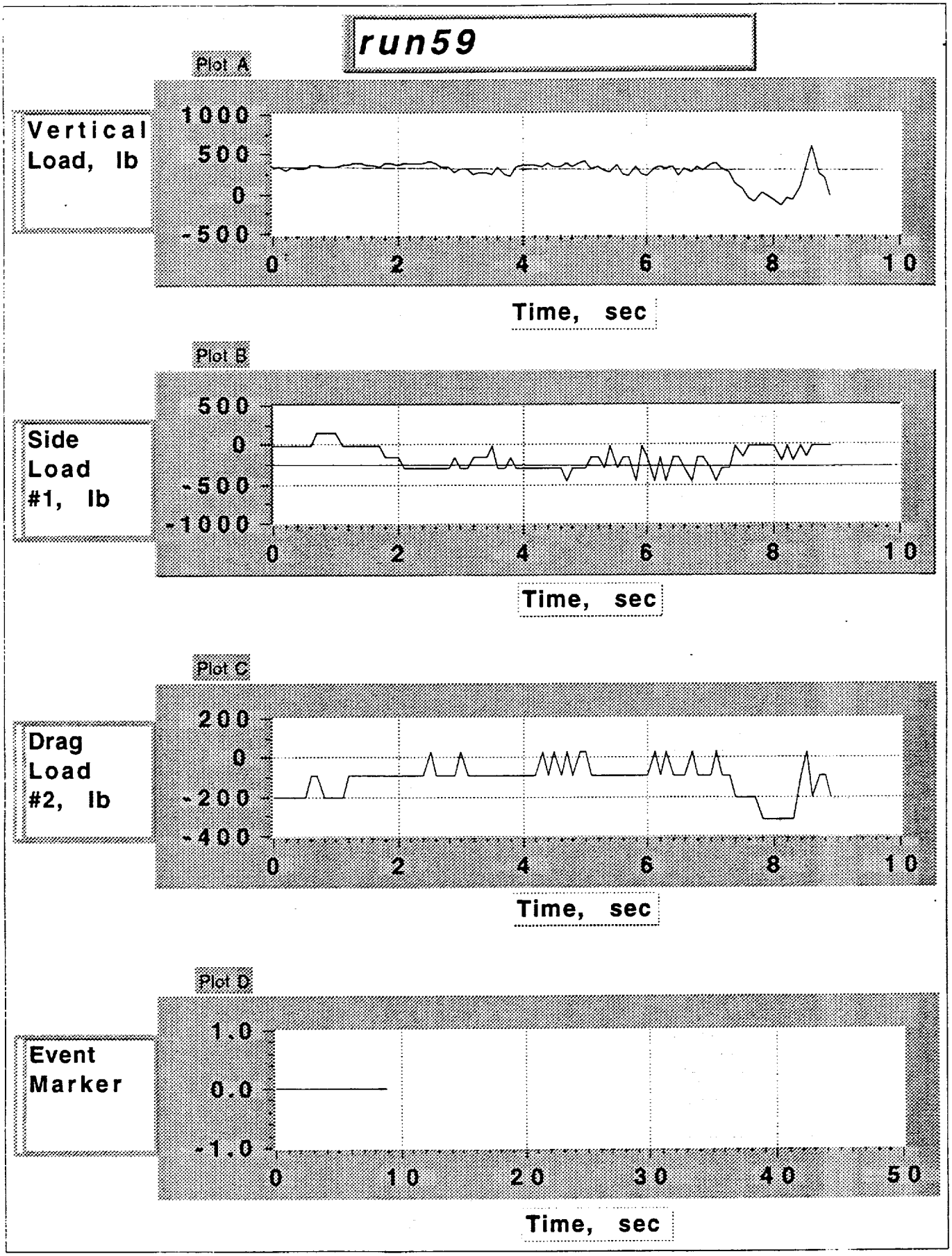

run54
Plot A
Vertical Load, lb
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
100
0
-100
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

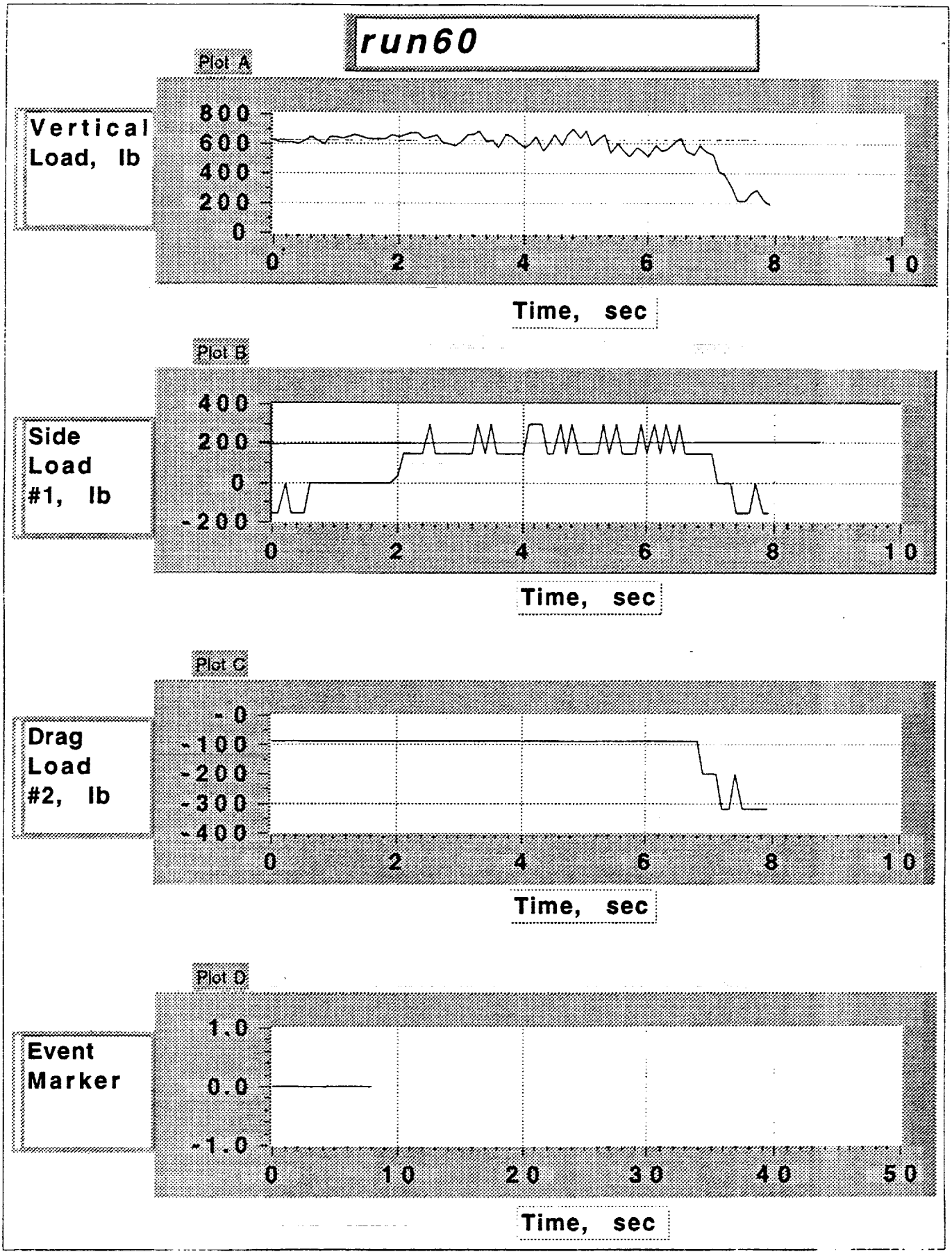

run55
Plot A
Vertical Load, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

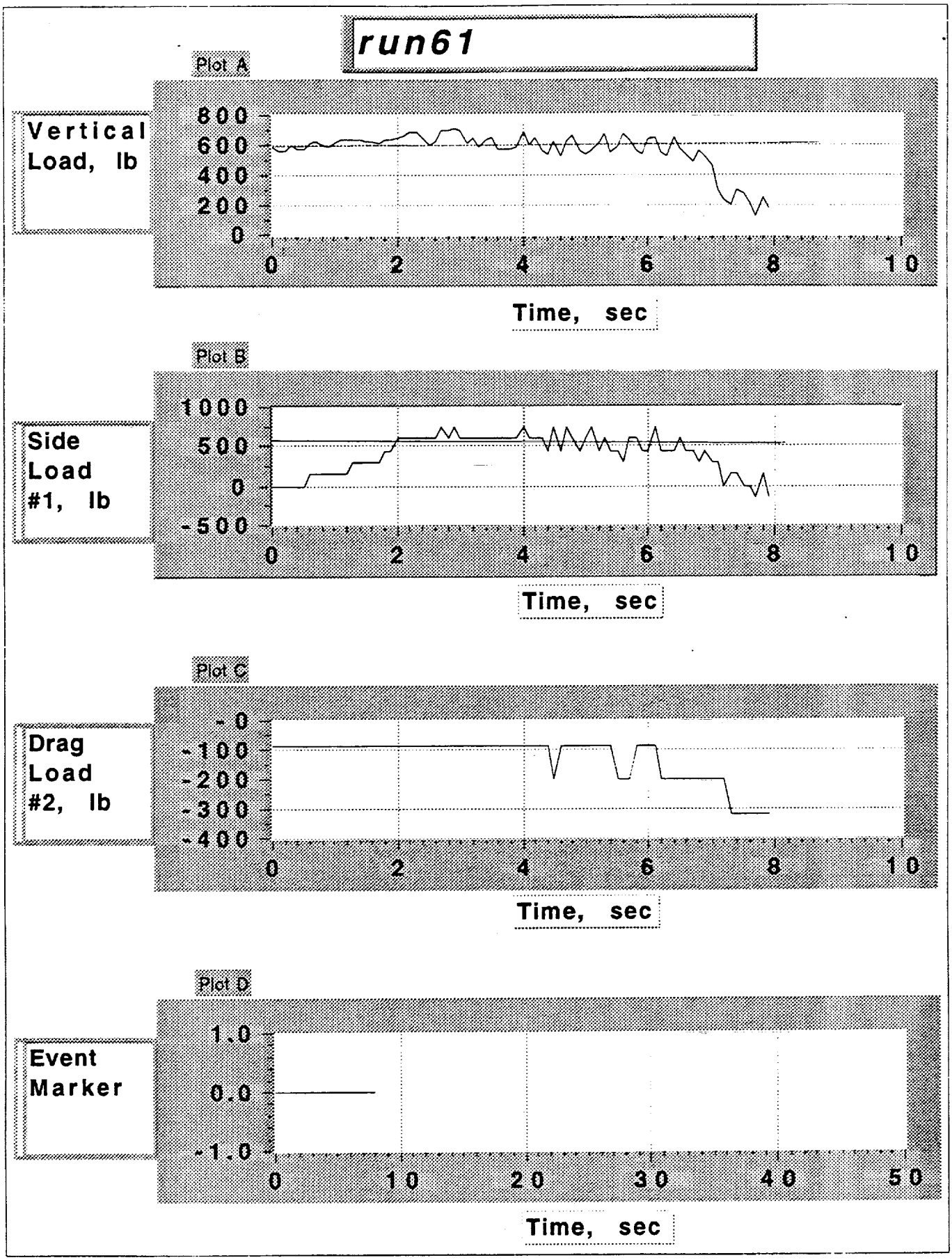

run56
Plot A
Vertical Load, lb
1000
800
600
400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
50
0
-50
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

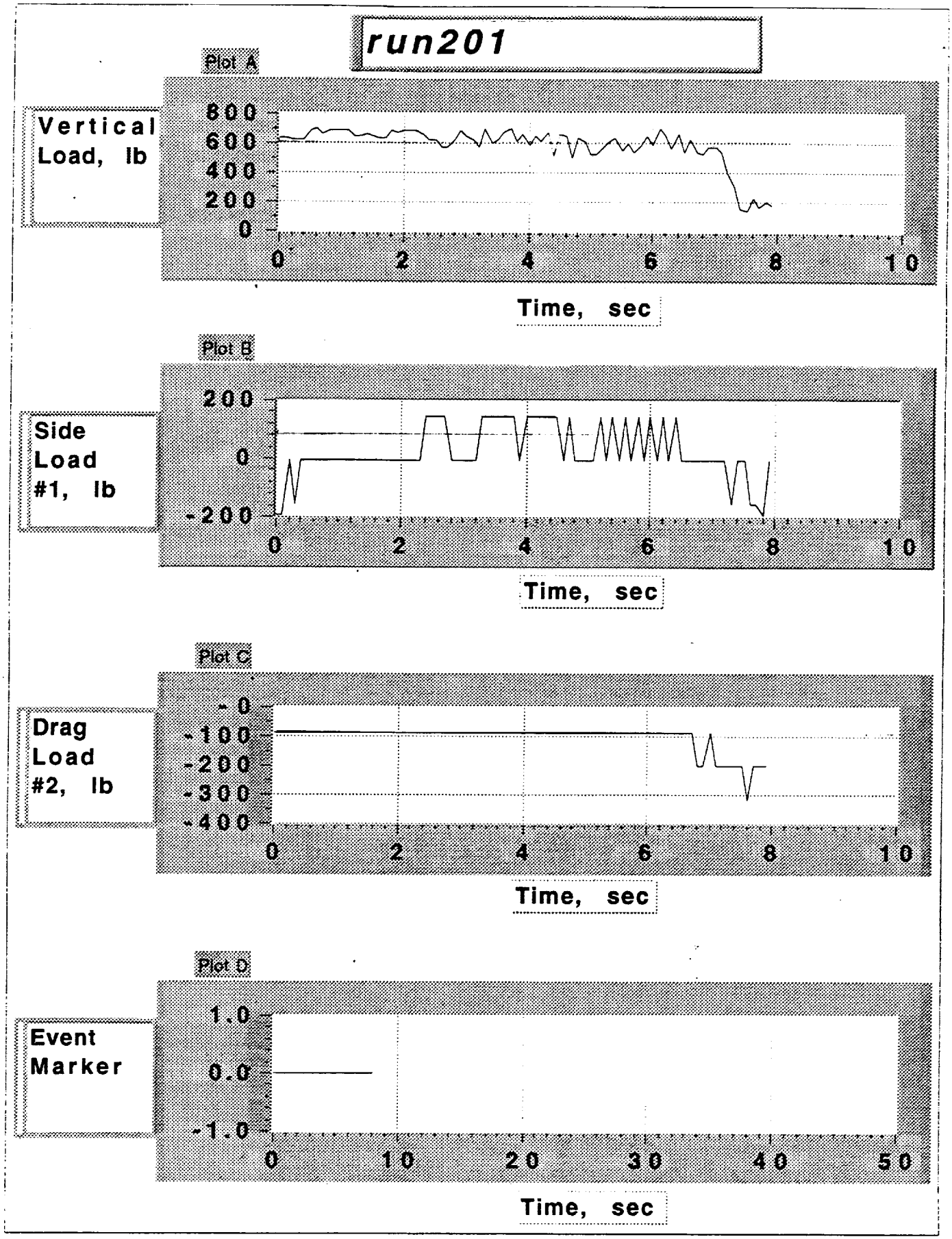

run57
Plot A
Vertical Load, lb
400
300
200
100
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-20
-40
-60
-80
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

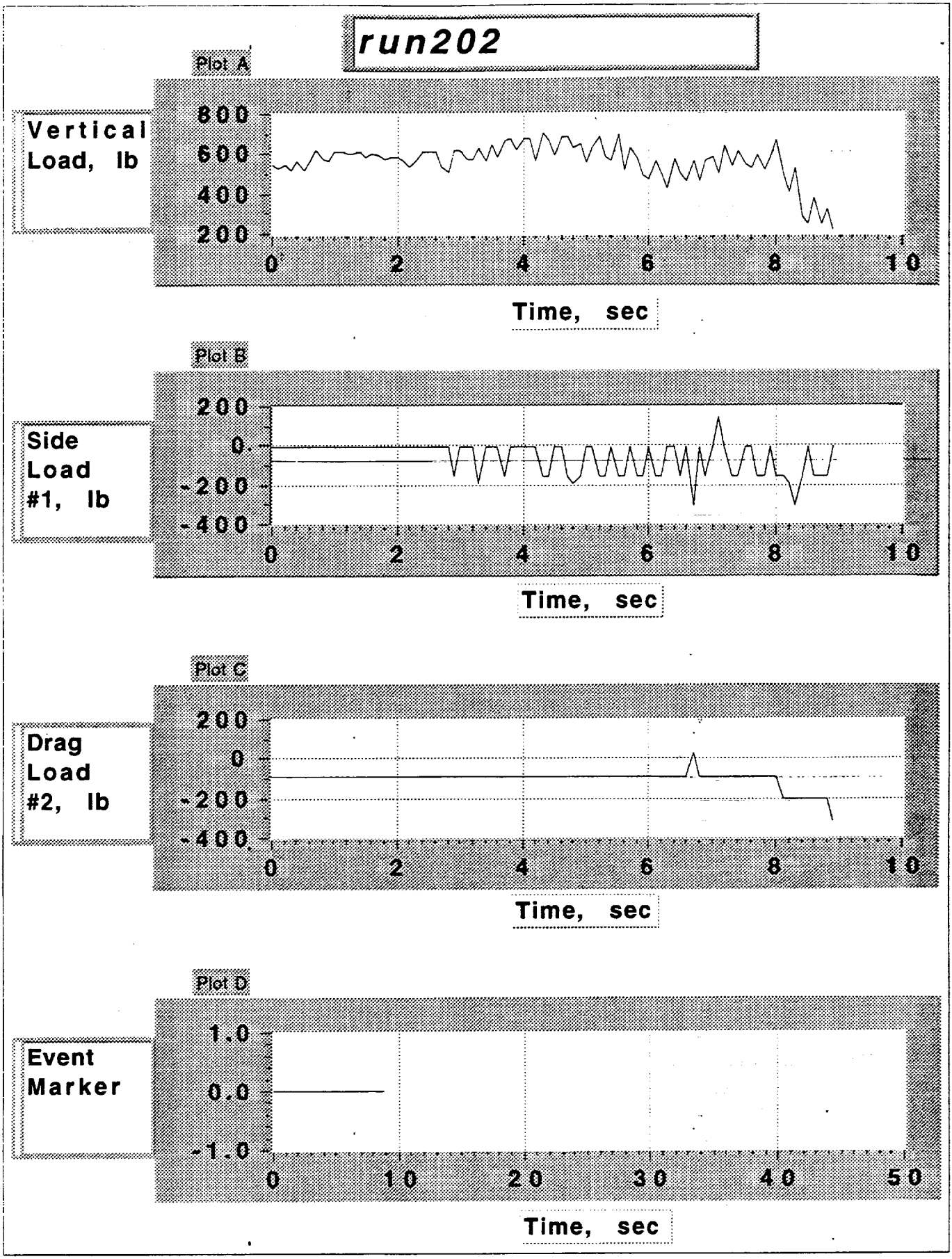

run58
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

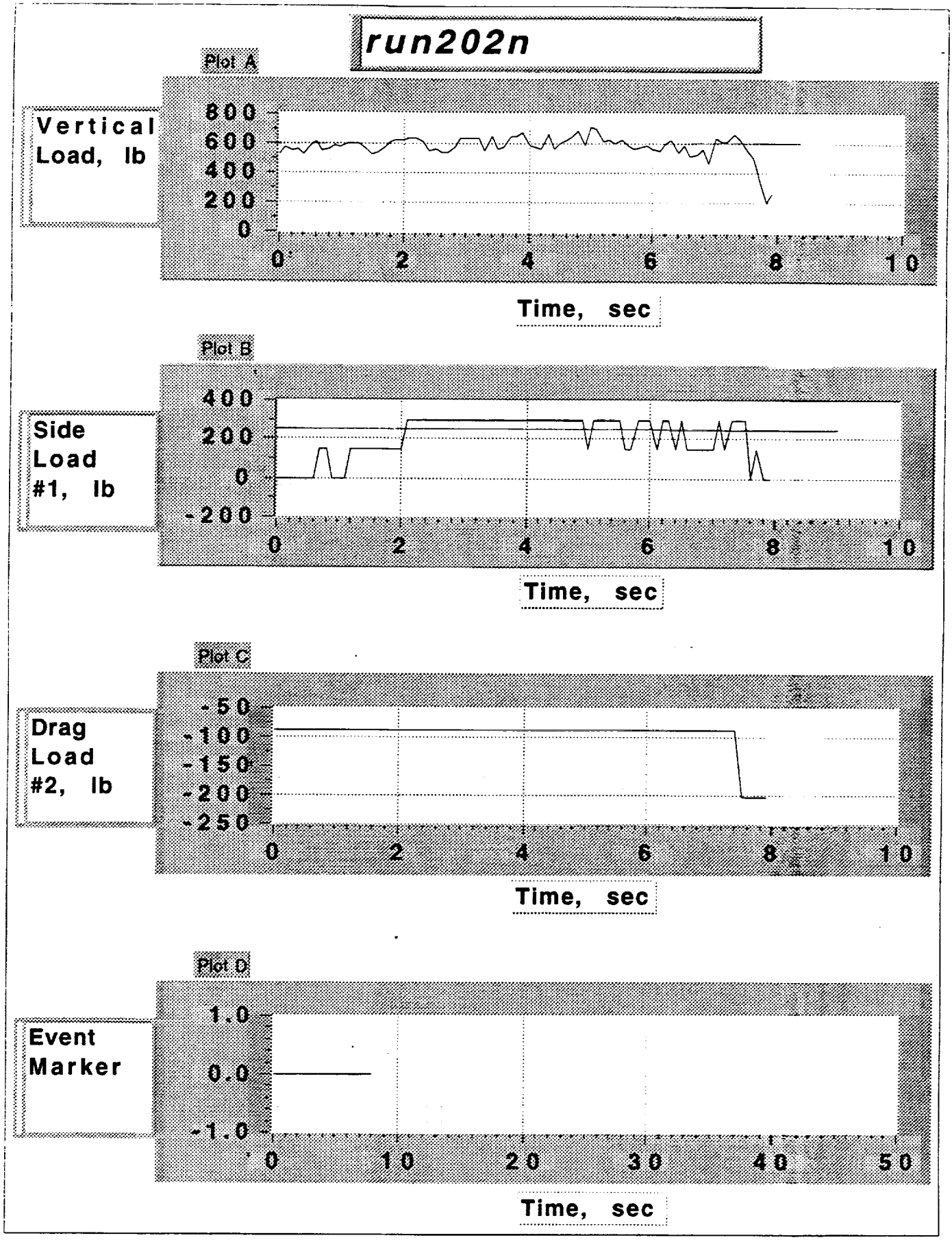

run59
Plot A
Vertical Load, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

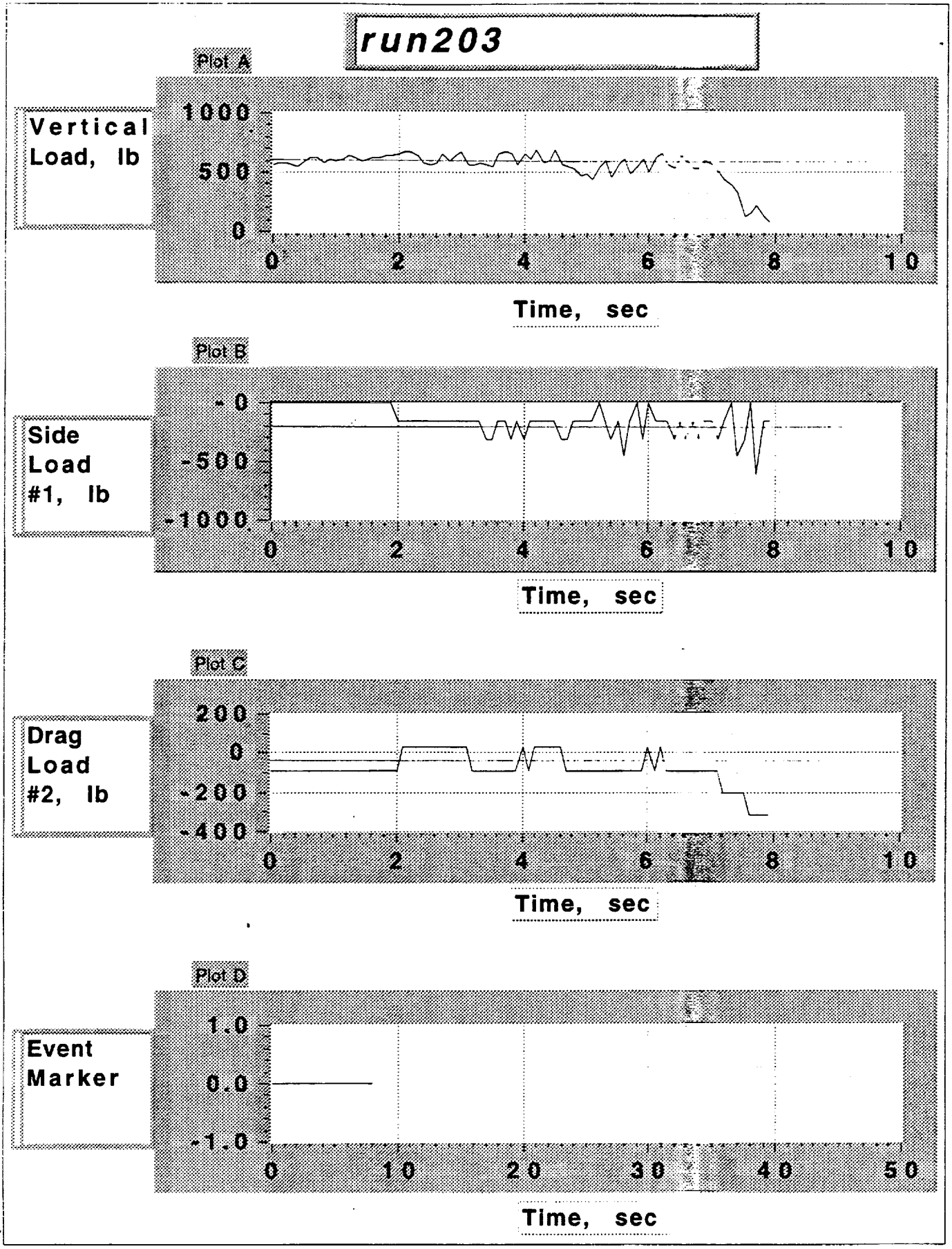

run60
Plot A
Vertical Load, lb
800
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
- 0
-100
-200
-300
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

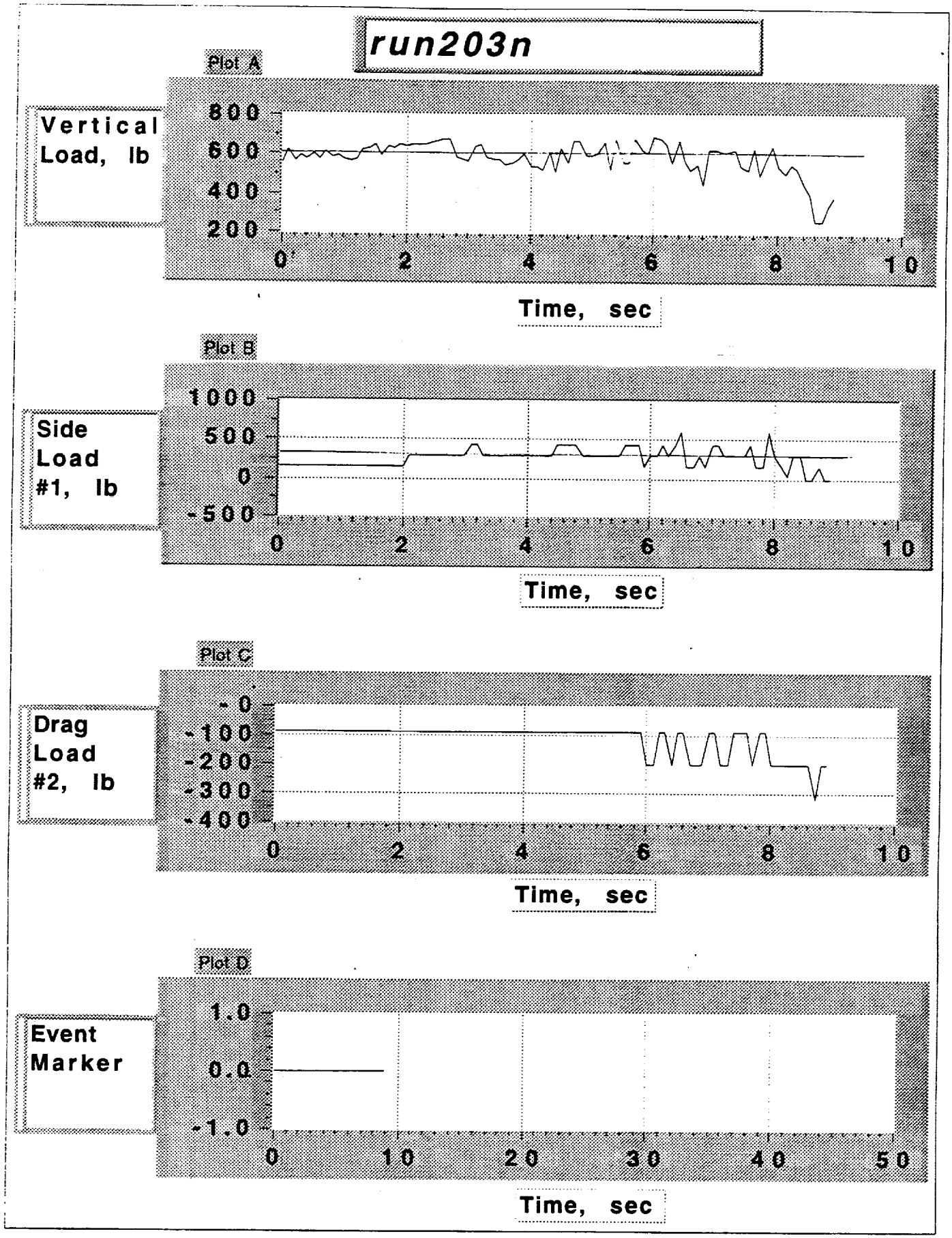

run61
Plot A
Vertical Load, lb
800
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

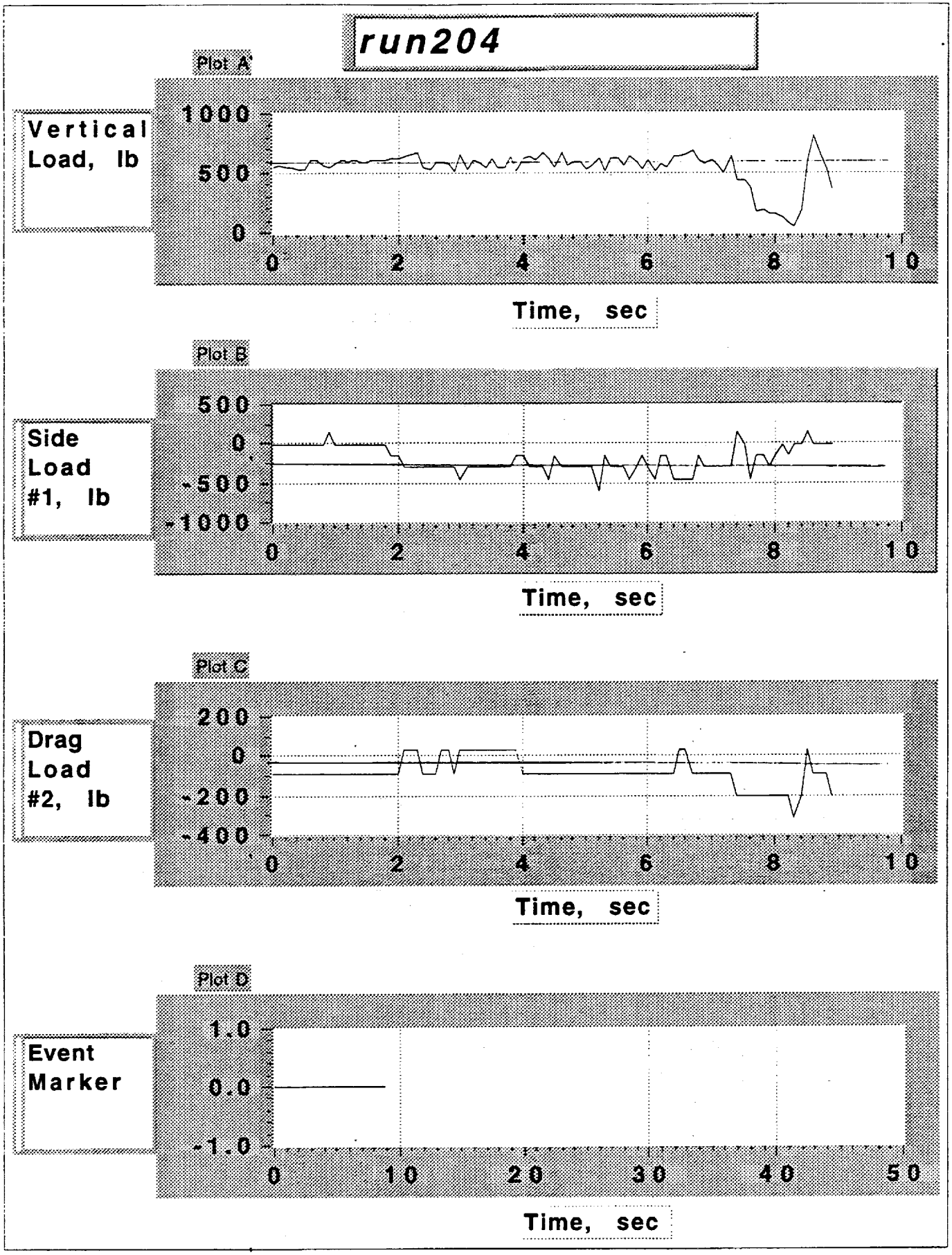

run201
Plot A
Vertical Load, lb
800
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

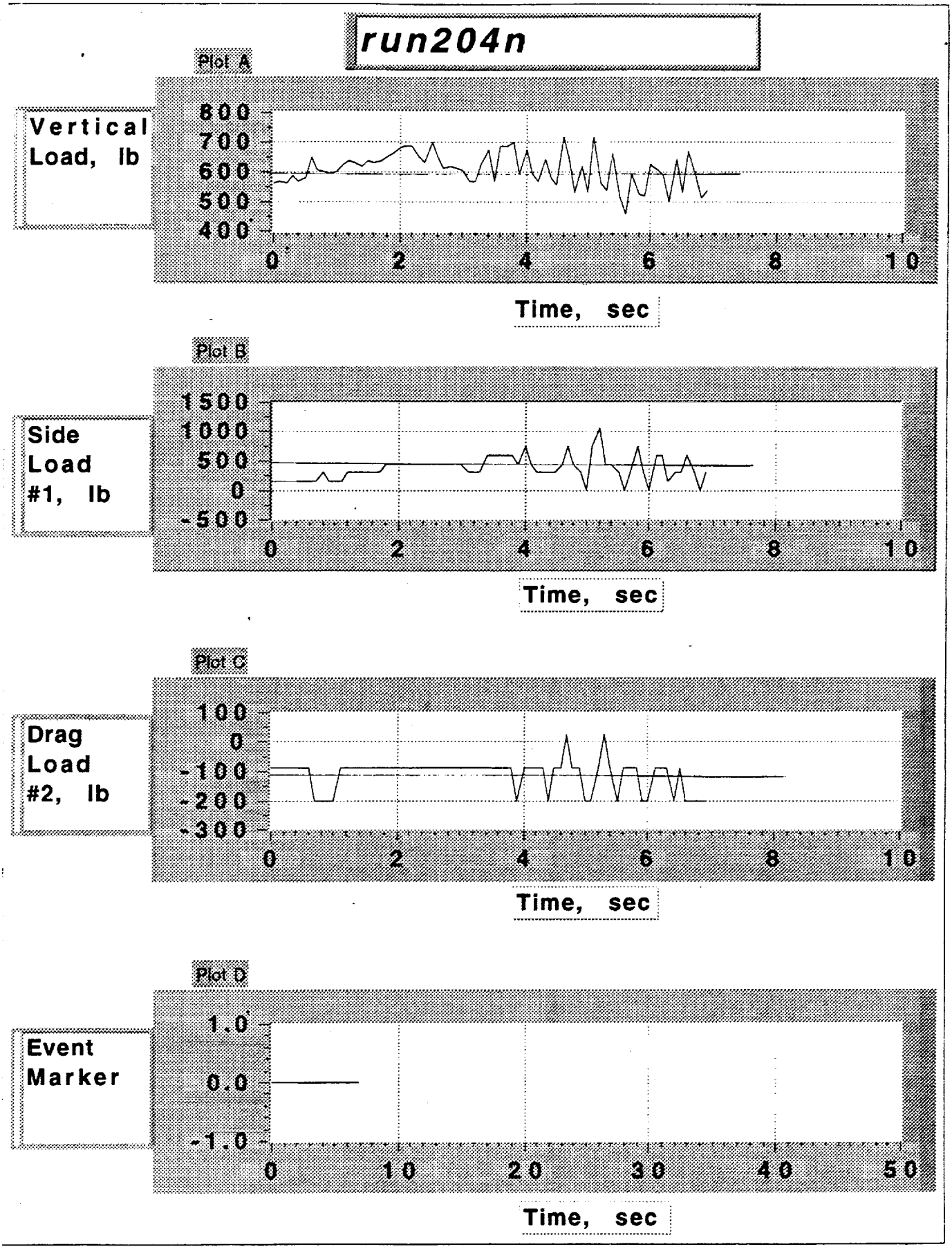

run202
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0.
-200
-400
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec


run202n
Plot A
Vertical Load, lb
800
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-50
-100
-150
-200
-250
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

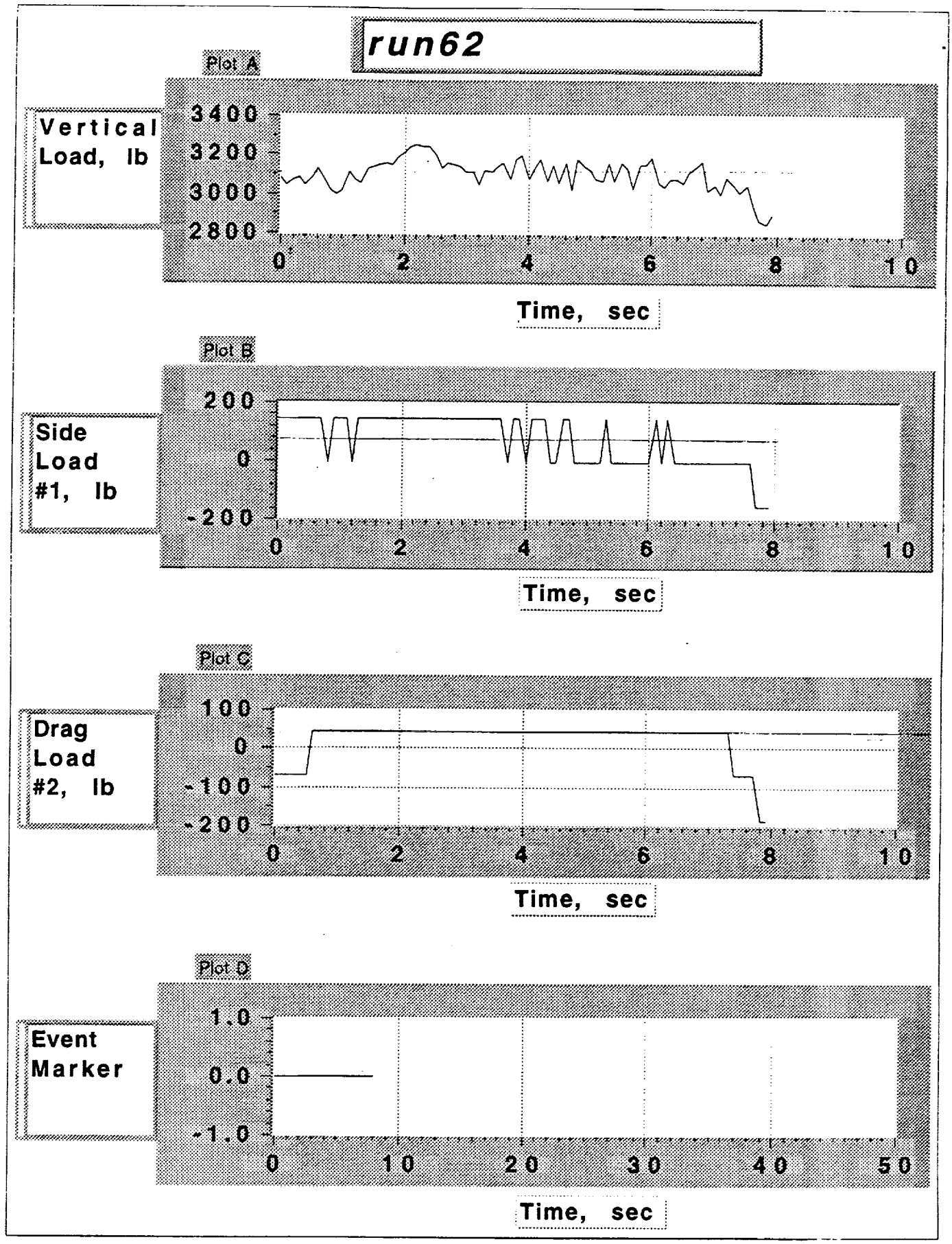

run203
Plot A
Vertical Load, lb
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
-0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

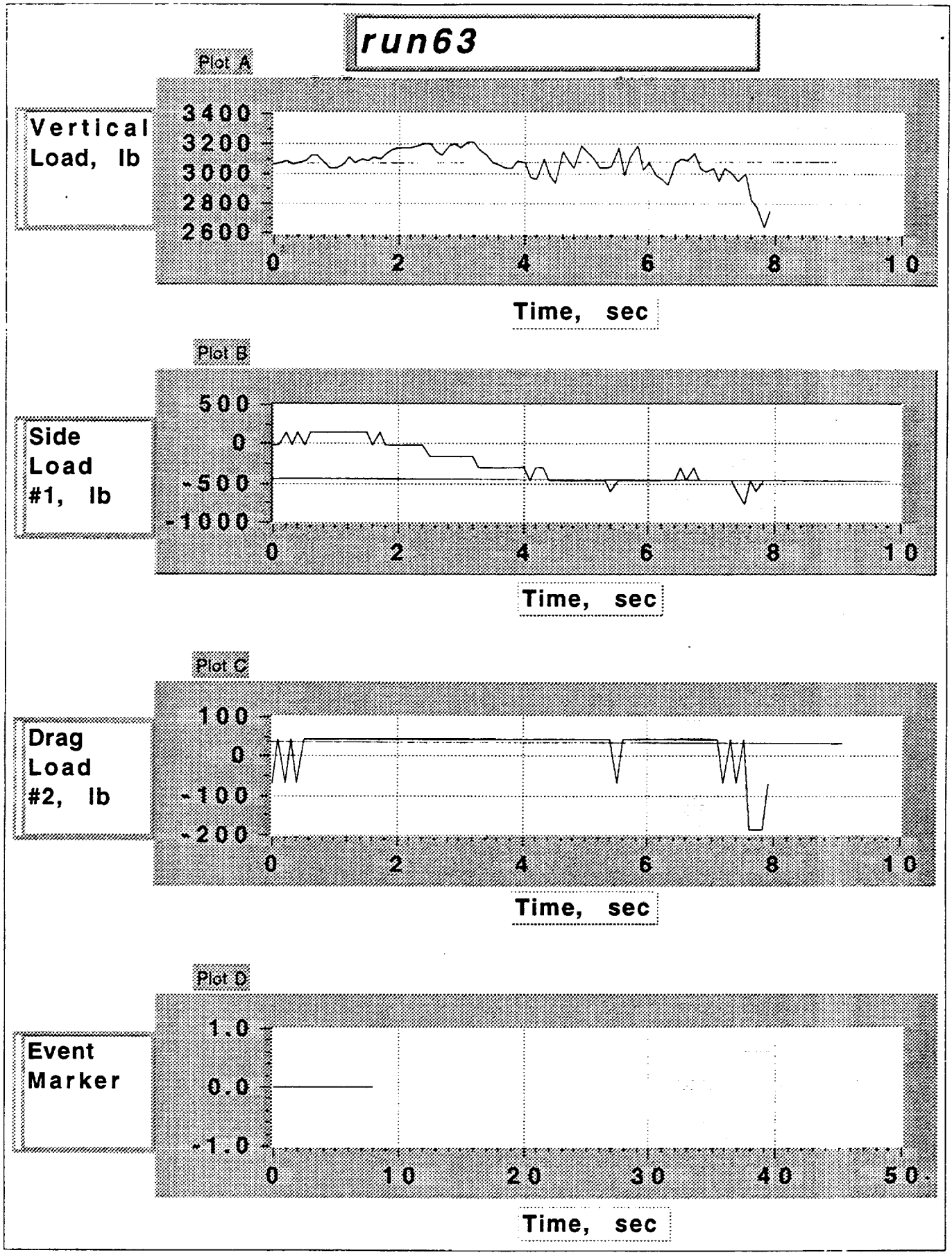

run203n
Plot A
Vertical Load, lb
800
600
400
200
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
-0
-100
-200
-300
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

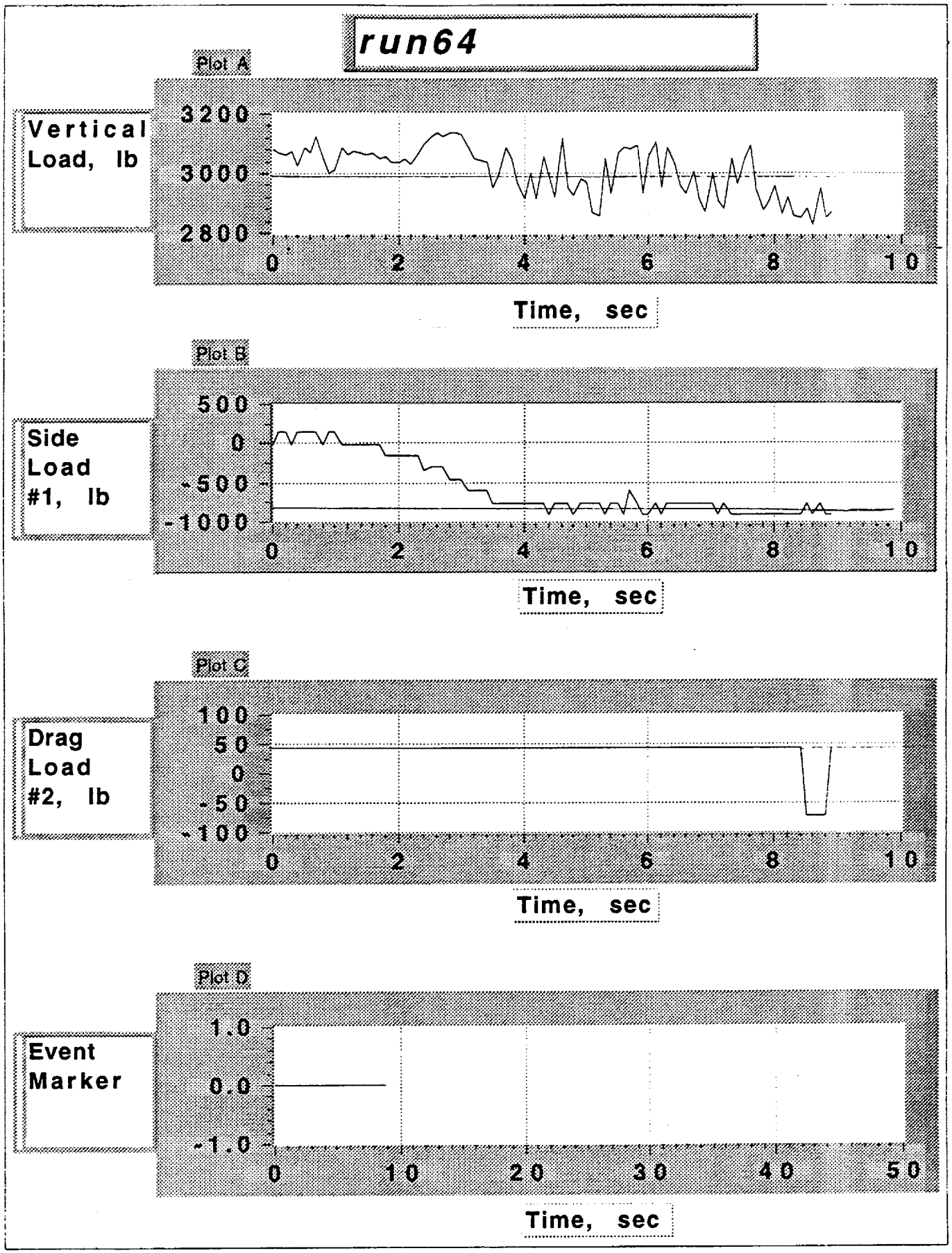

run204
Plot A
Vertical Load, lb
1000
500
0
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

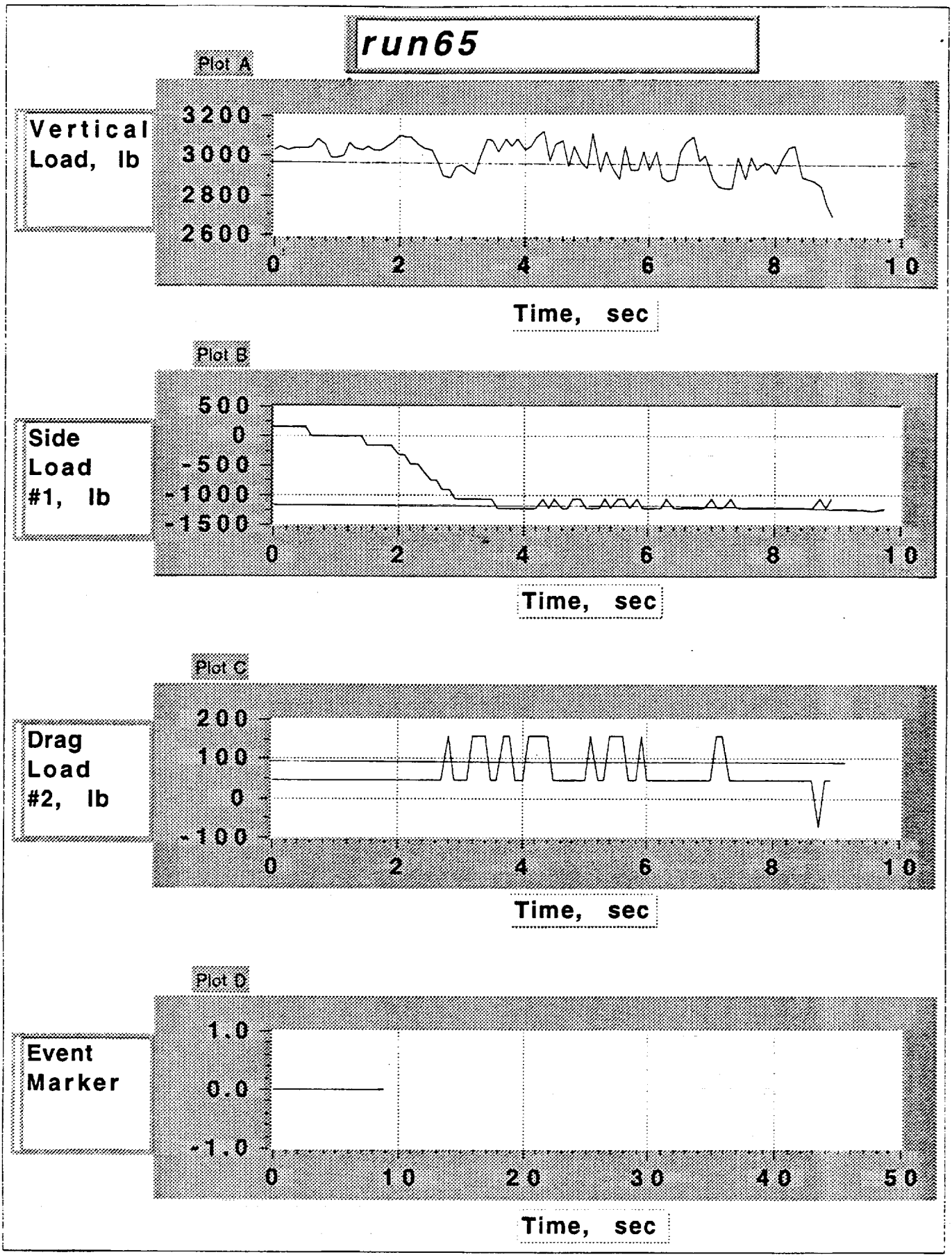

run204n
Plot A
Vertical Load, lb
800
700
600
500
400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1500
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
-300
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

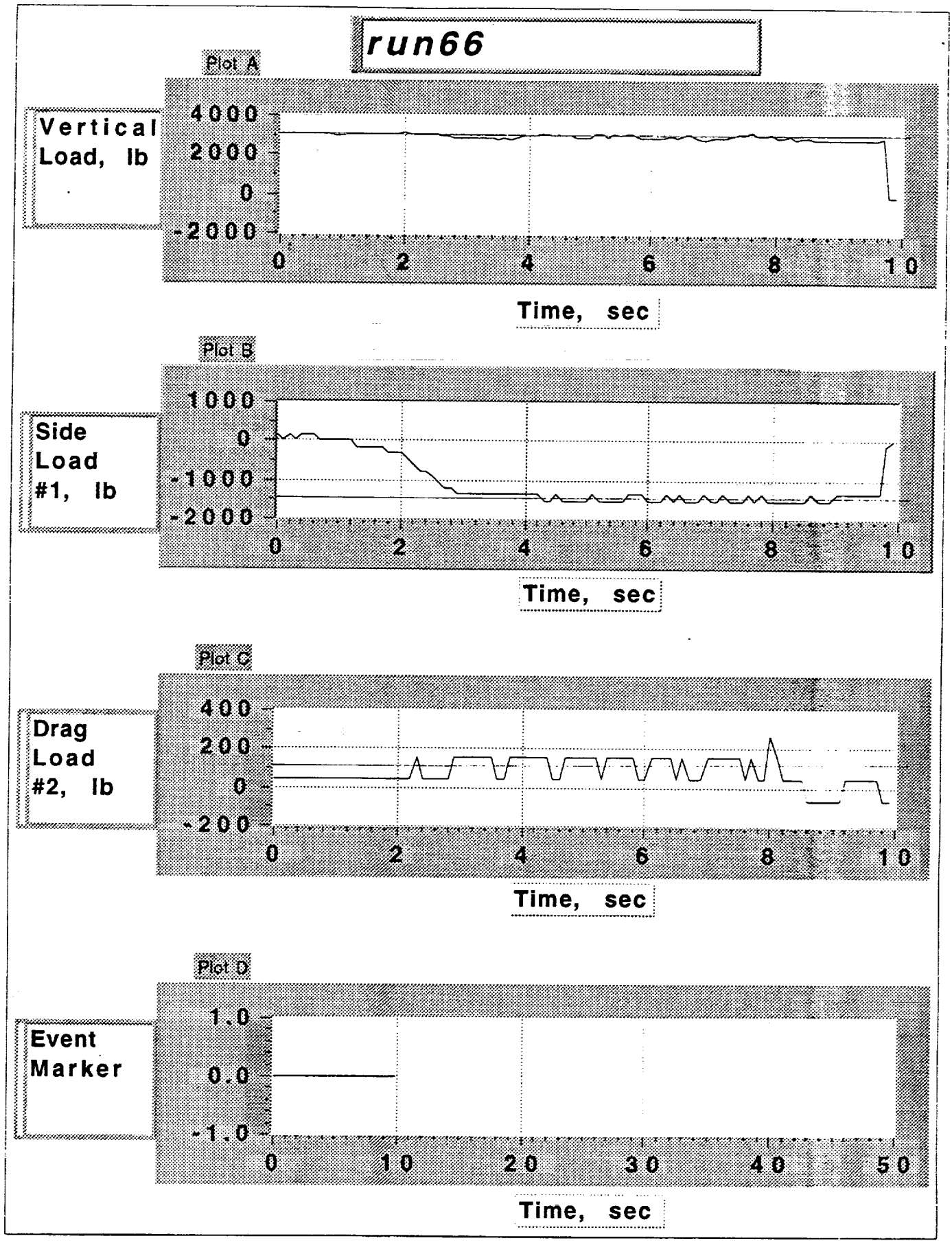
T-45 Main Gear Tire Test Run Parameter Time Histories

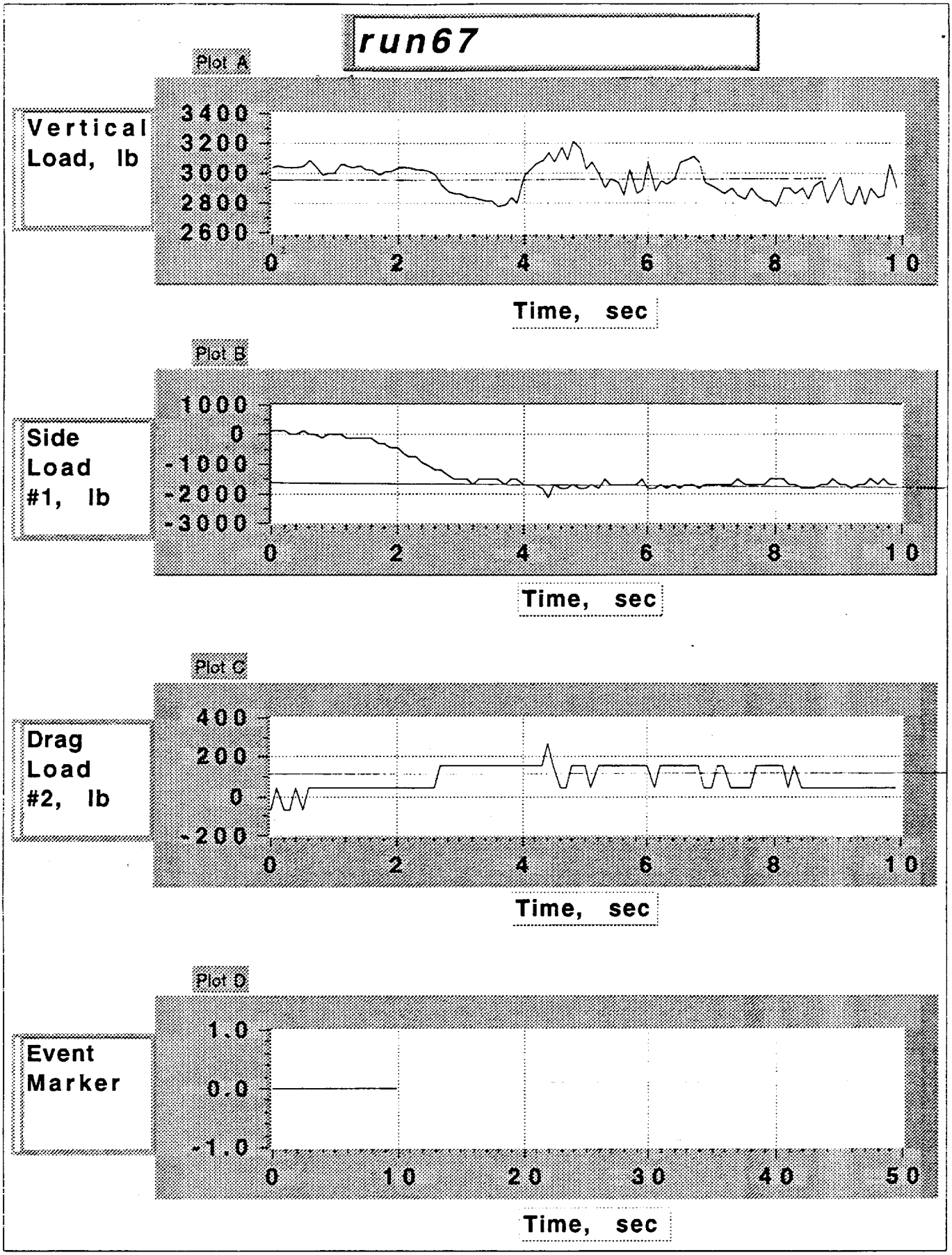

run62
Plot A
Vertical Load, lb
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

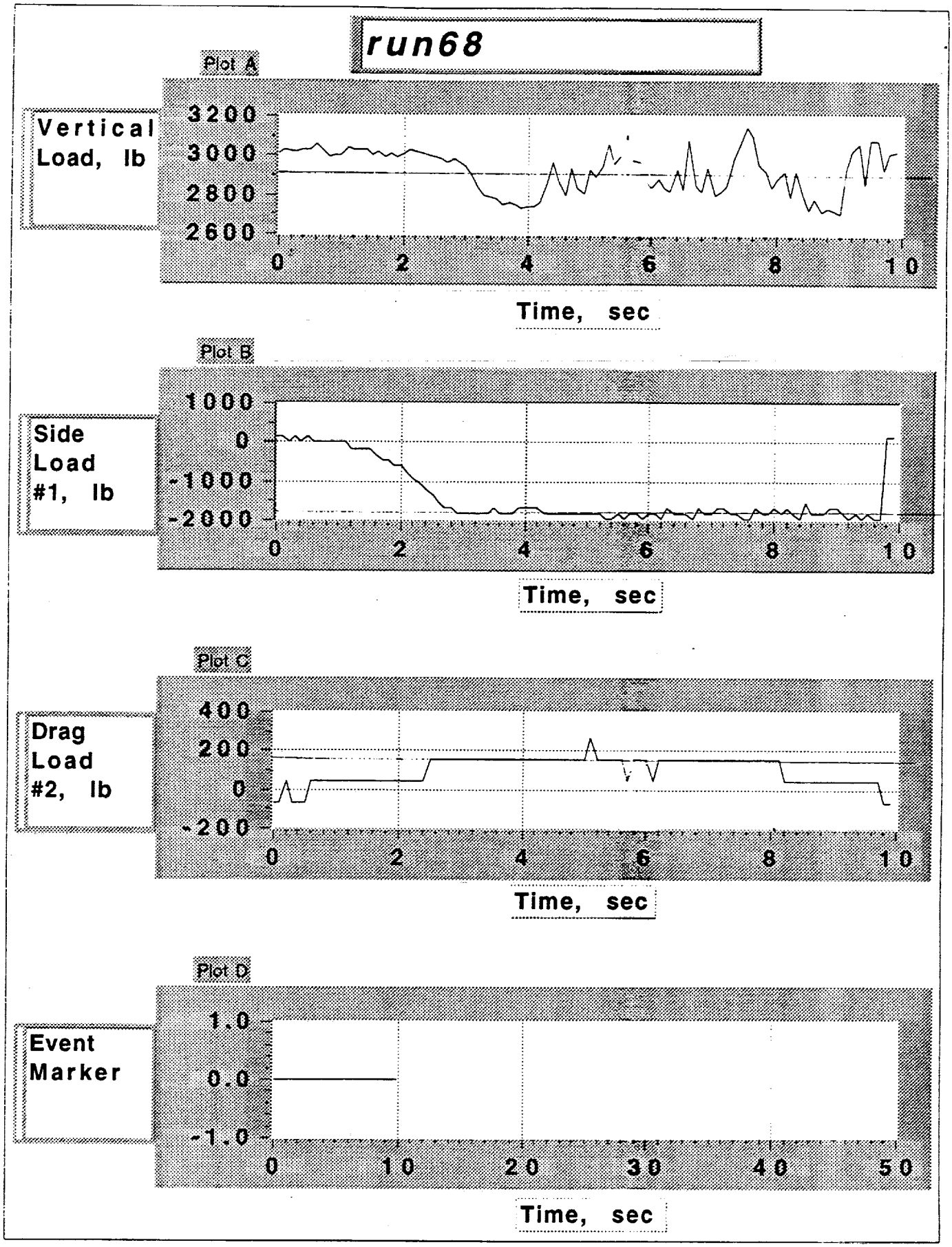

run63
Plot A
Vertical Load, lb
3400
3200
3000
2800
2600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

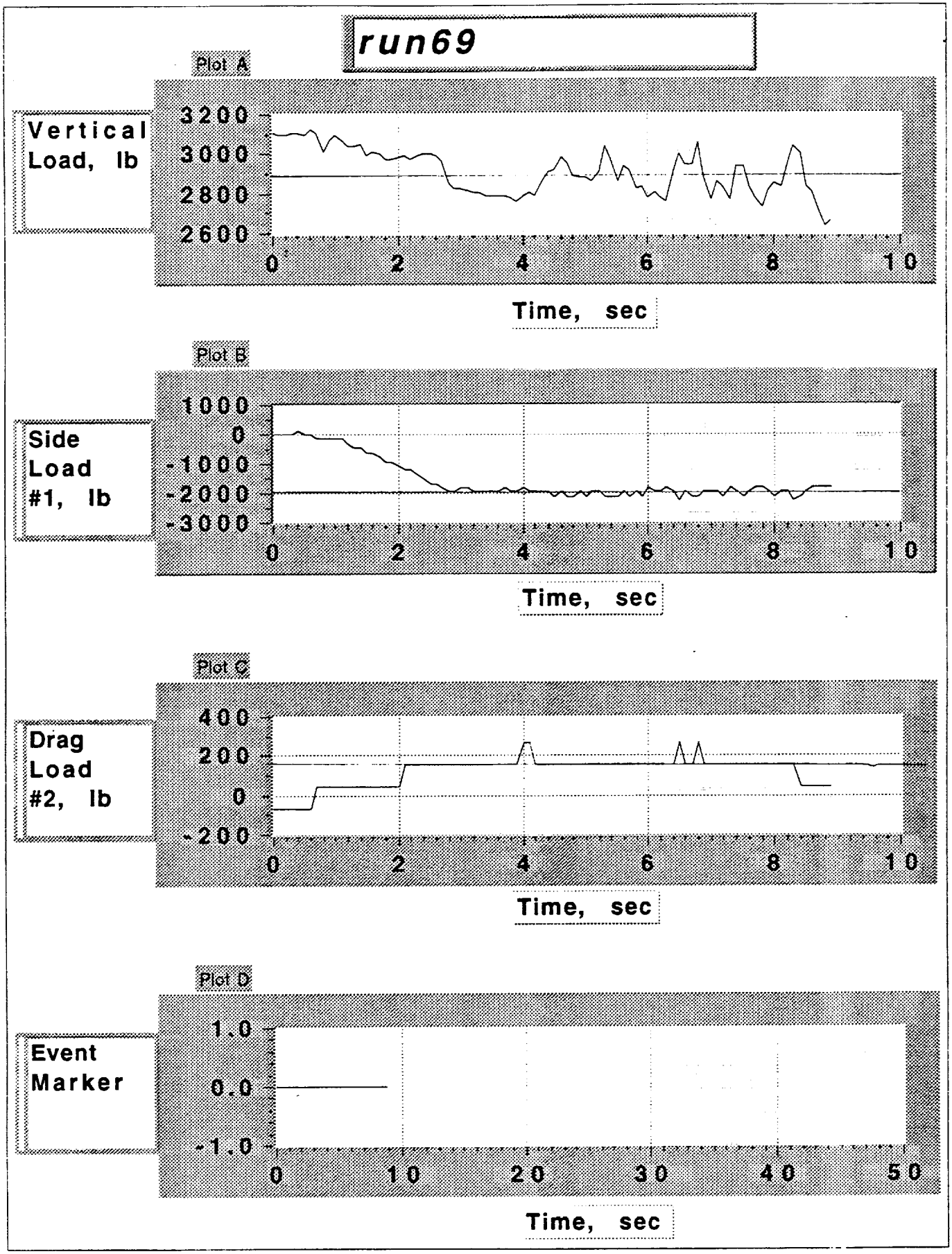

run64
Plot A
Vertical Load, lb
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
50
0
-50
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

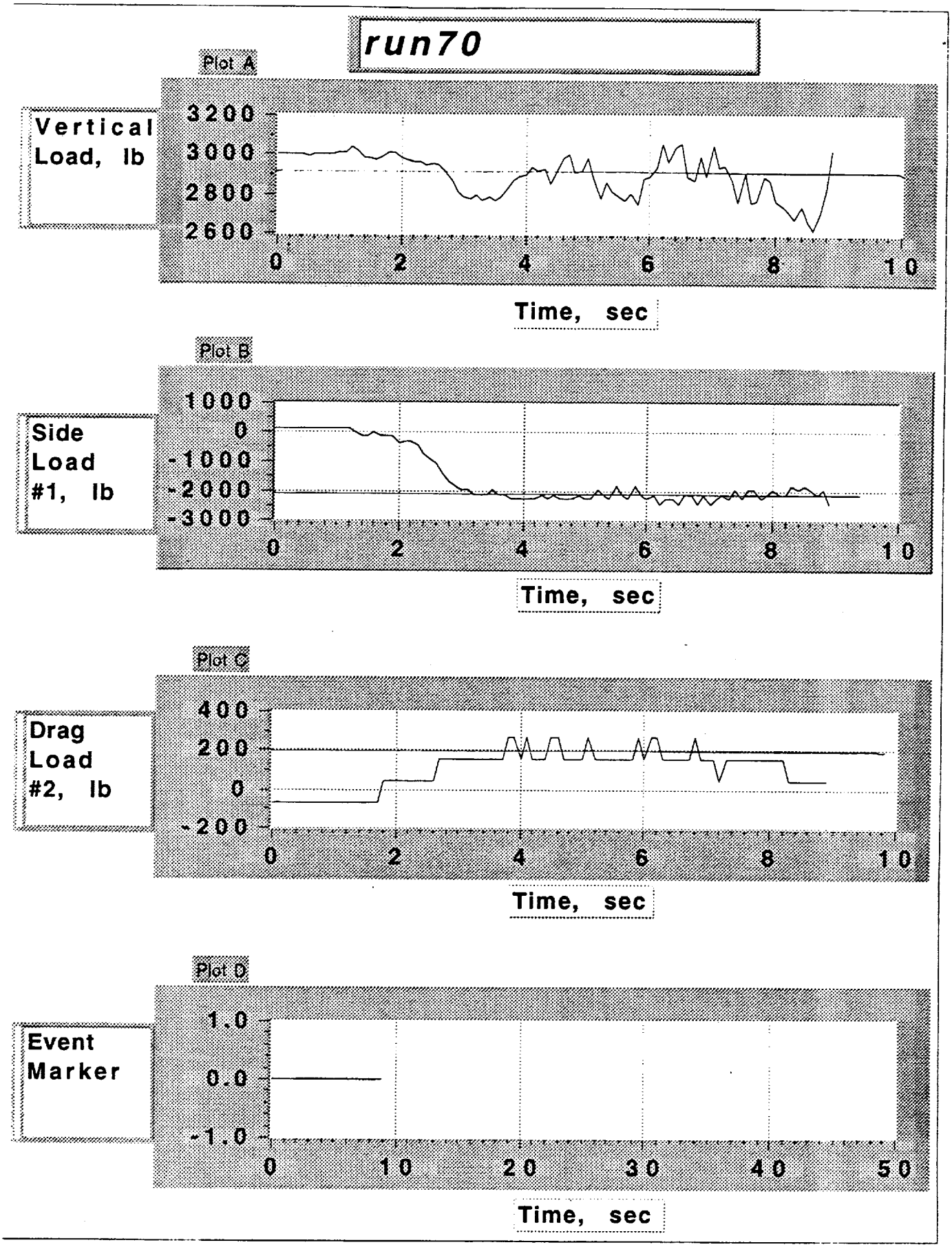

run65
Plot A
Vertical Load, lb
3200
3000
2800
2600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
-1500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

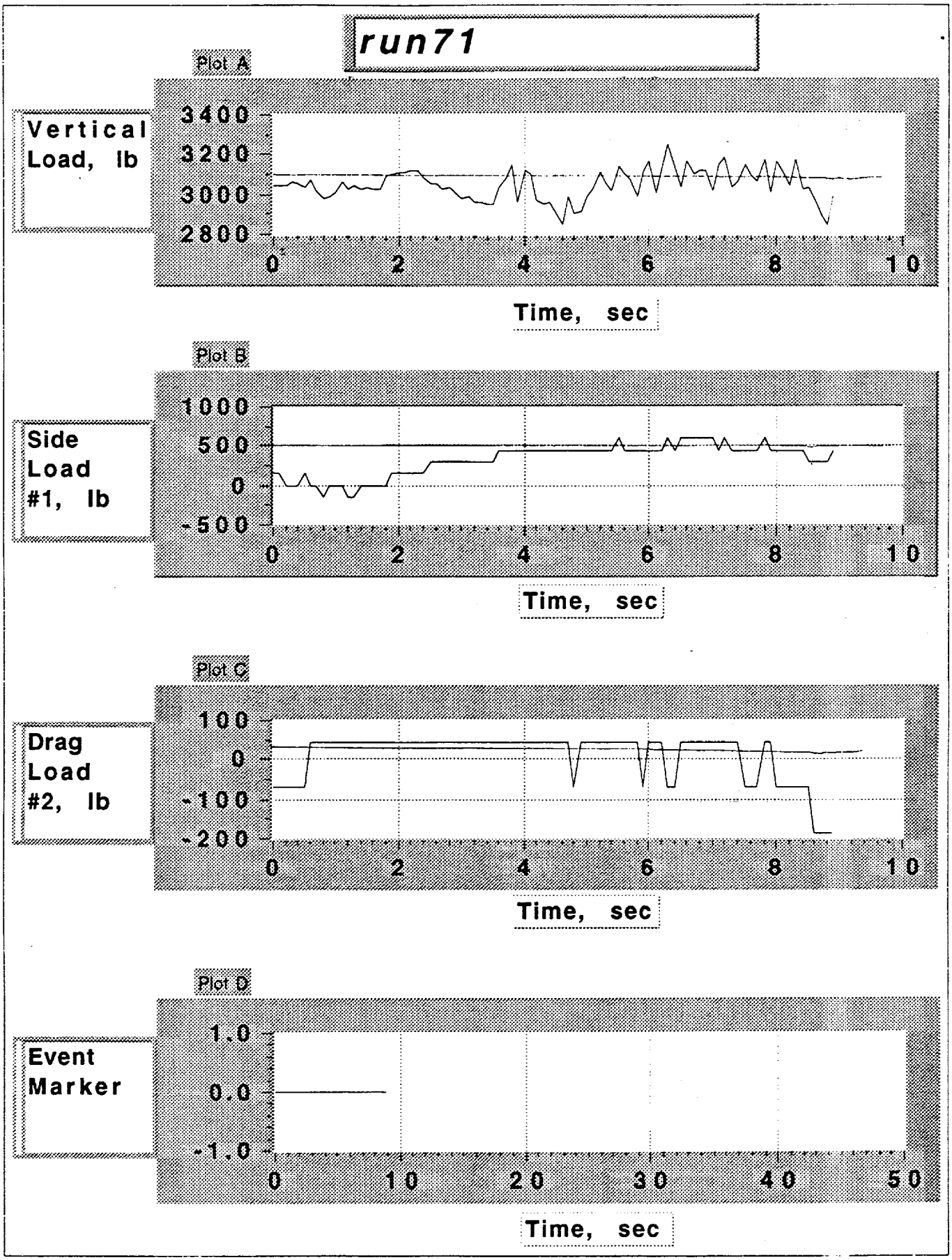

run66
Plot A
Vertical Load, lb
4000
2000
0
-2000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

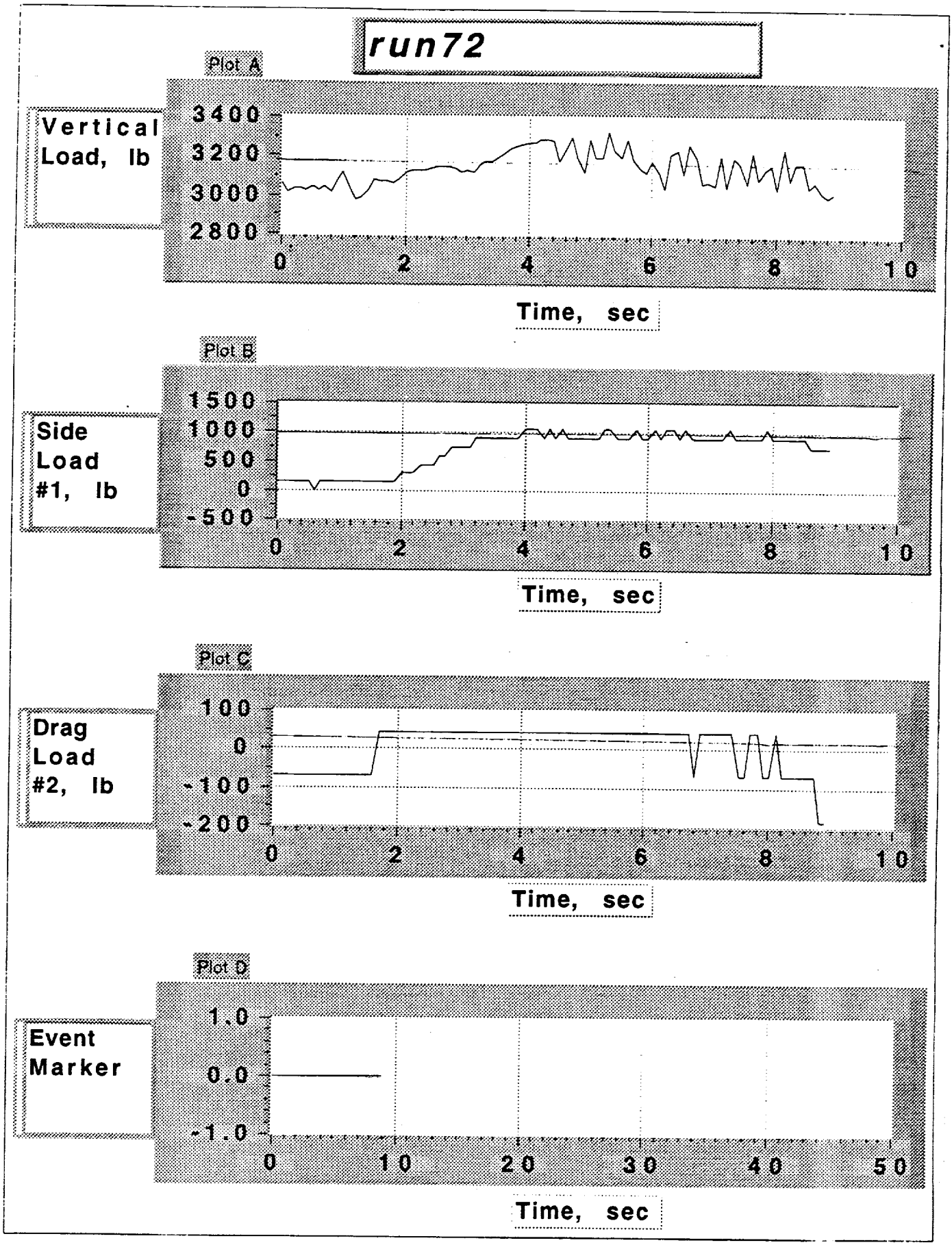

run67
Plot A
Vertical Load, lb
3400
3200
3000
2800
2600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
-3000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

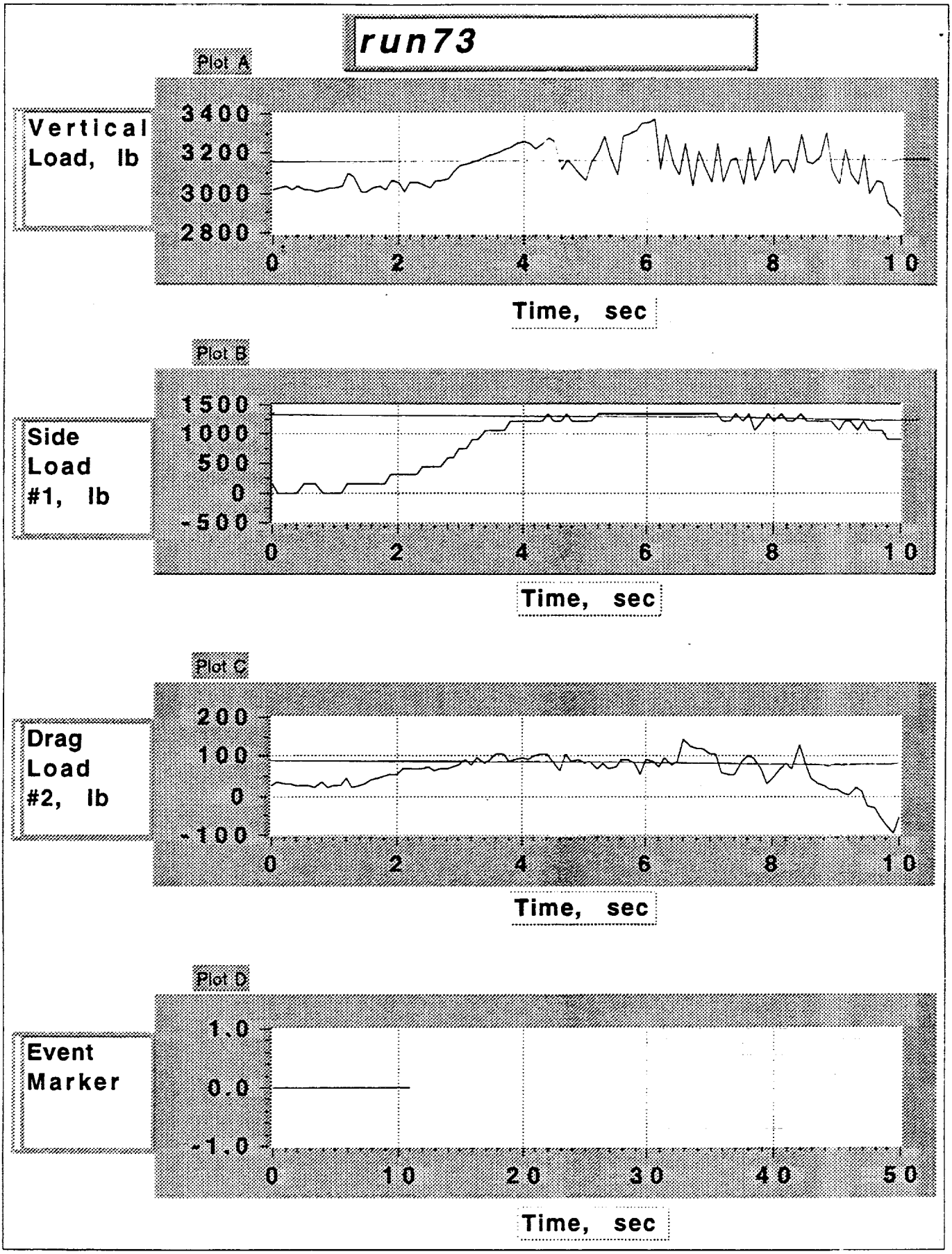

run68
Plot A
Vertical Load, lb
3200
3000
2800
2600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

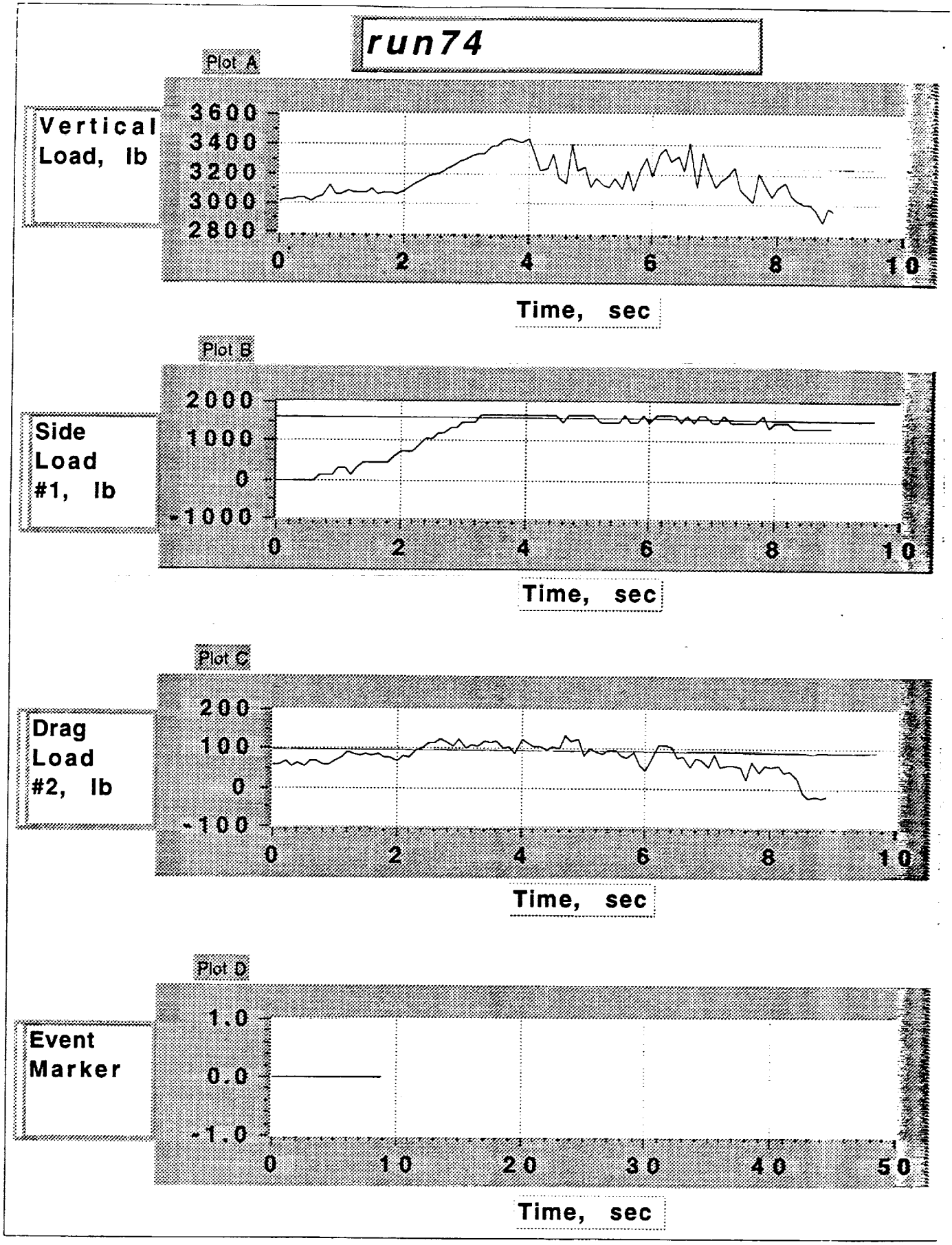

run69
Plot A
Vertical Load, lb
3200
3000
2800
2600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
-3000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

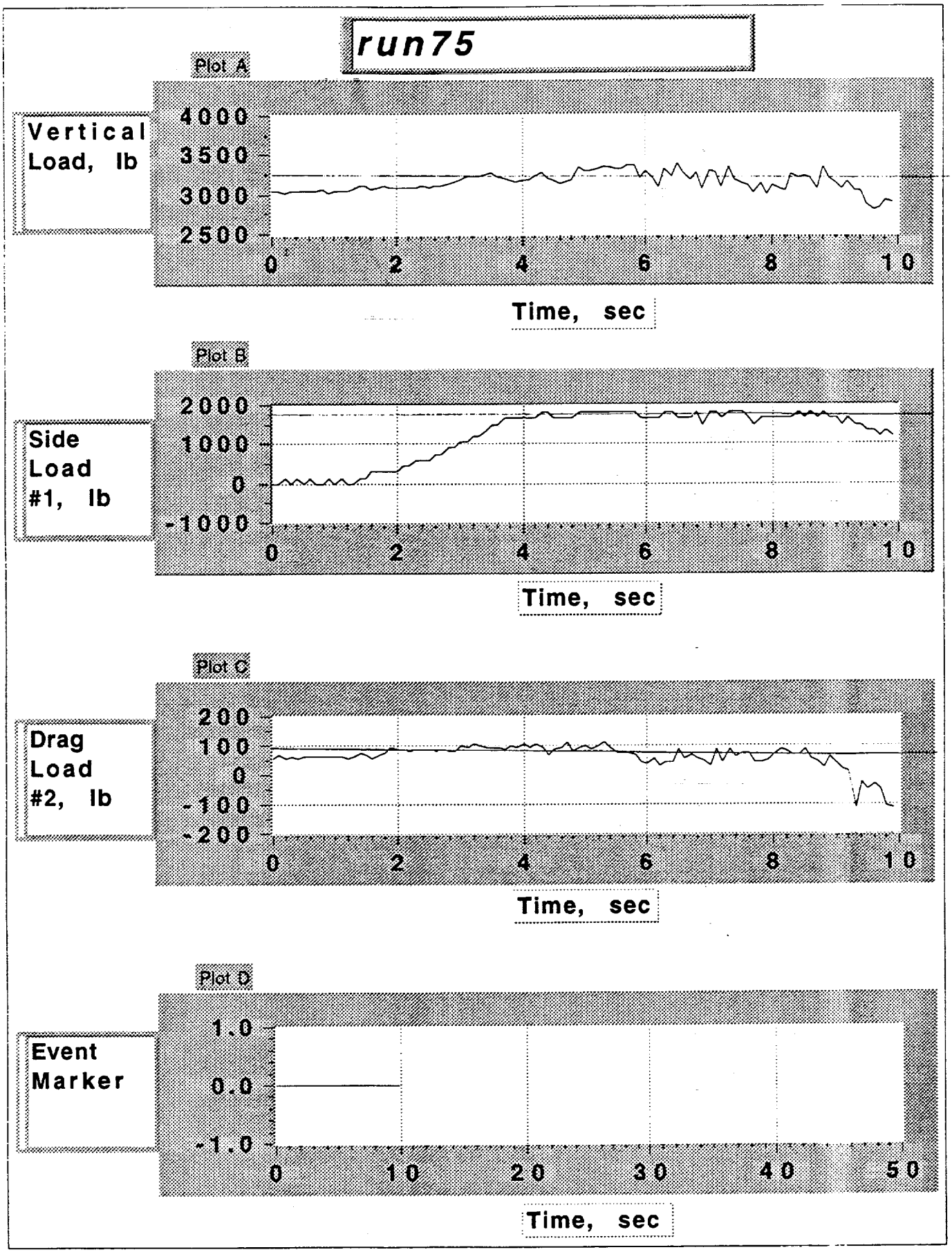

run70
Plot A
Vertical Load, lb
3200
3000
2800
2600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
-3000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

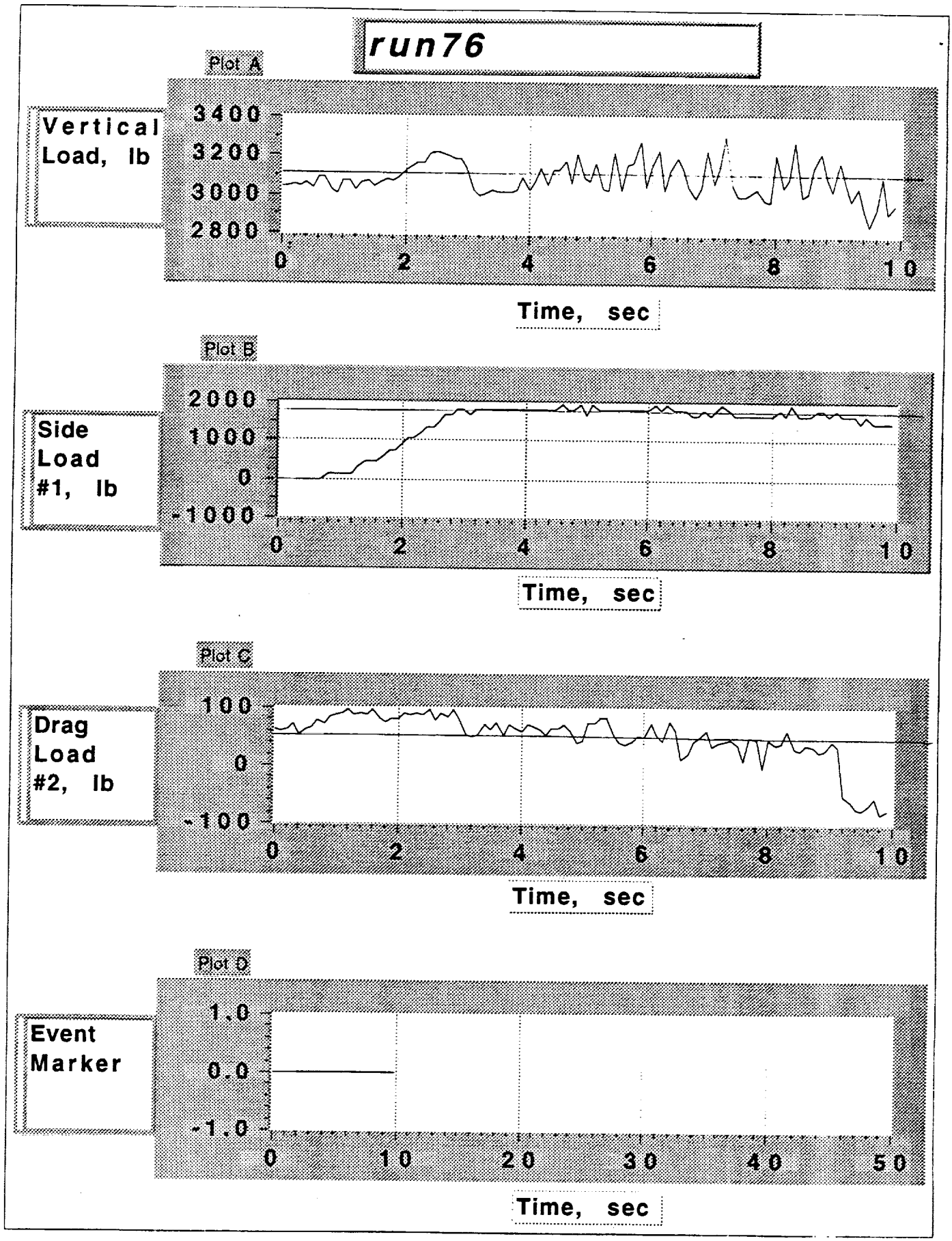

run71
Plot A
Vertical Load, lb
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

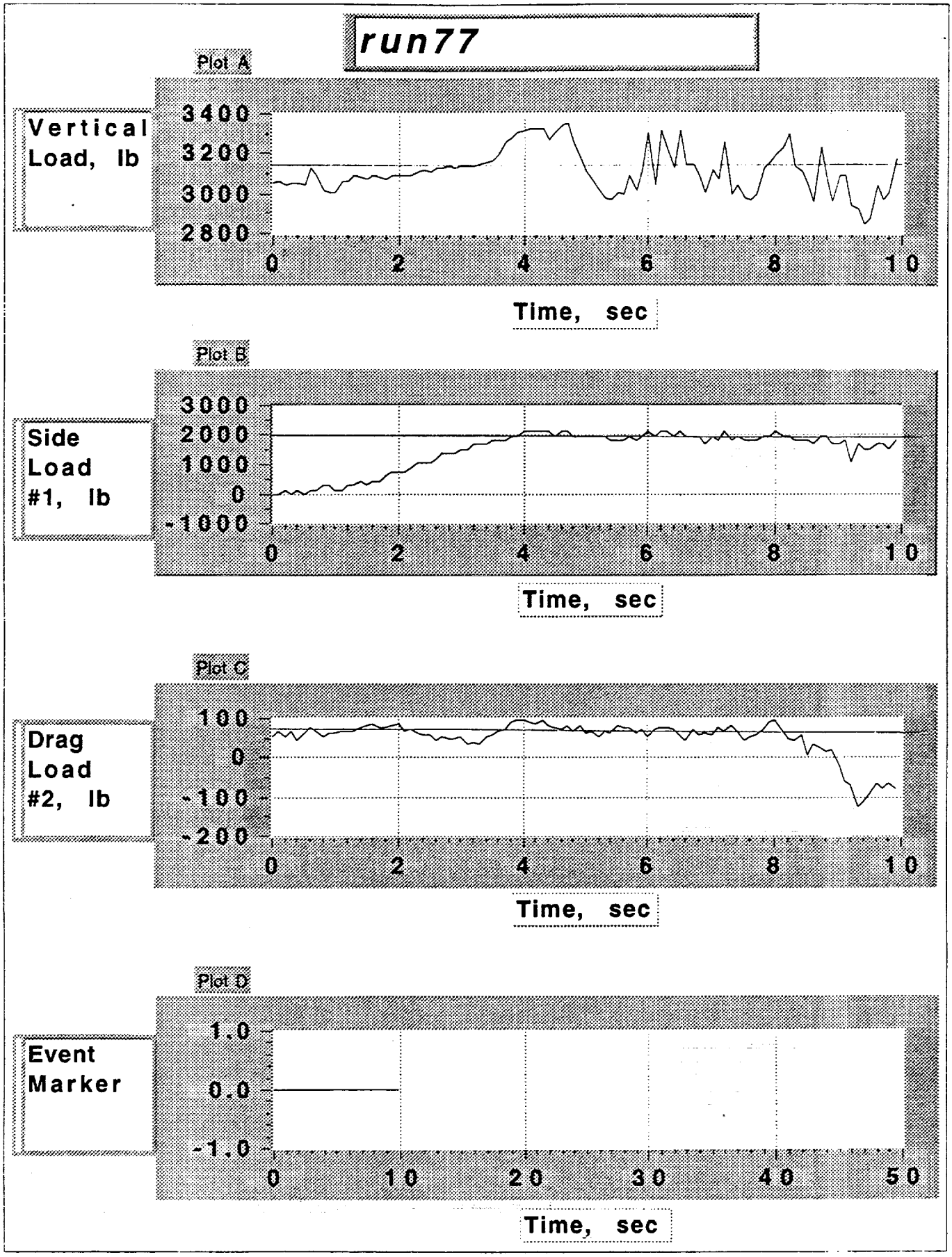

run72
Plot A
Vertical Load, lb
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1500
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

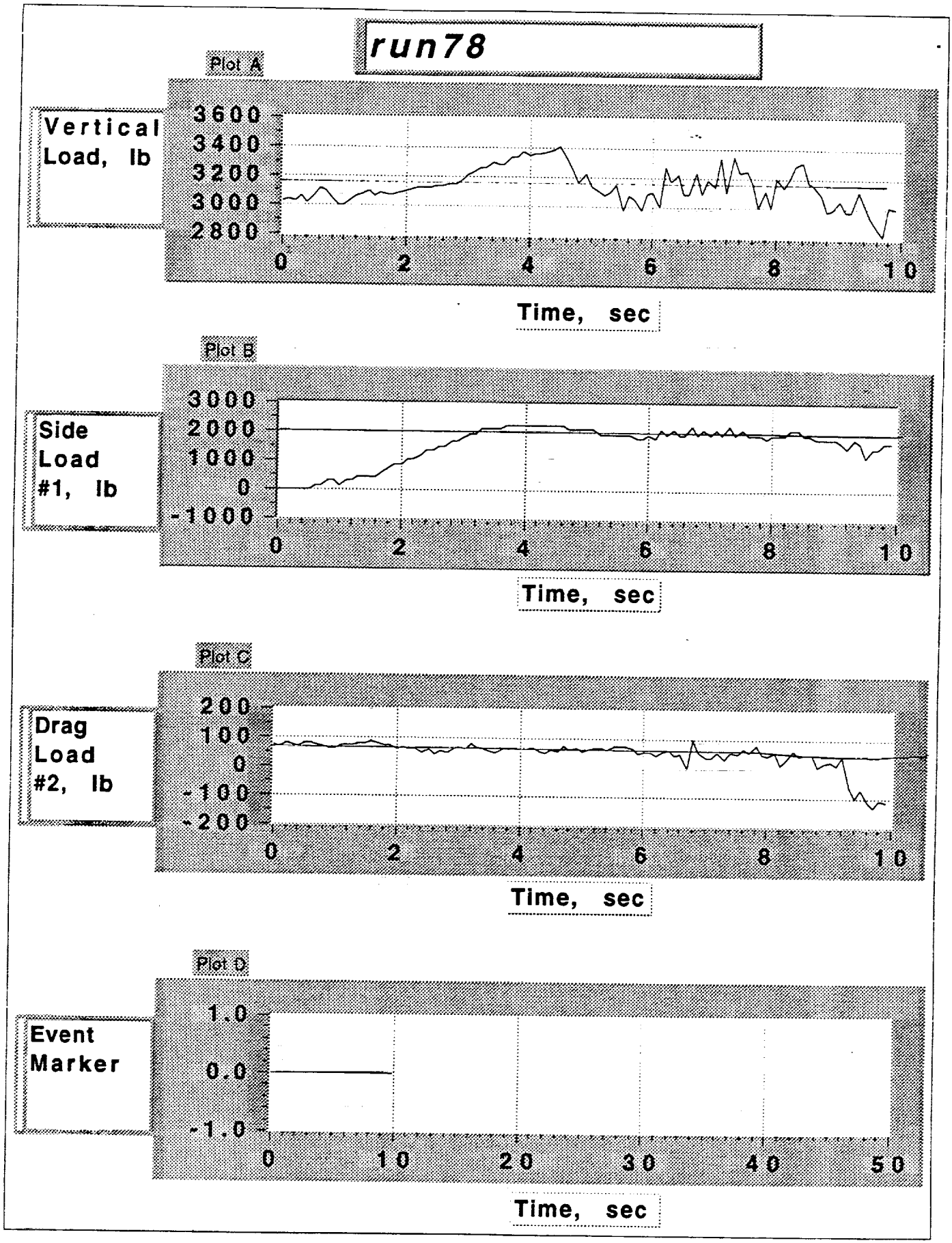

run73
Plot A
Vertical Load, lb
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1500
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

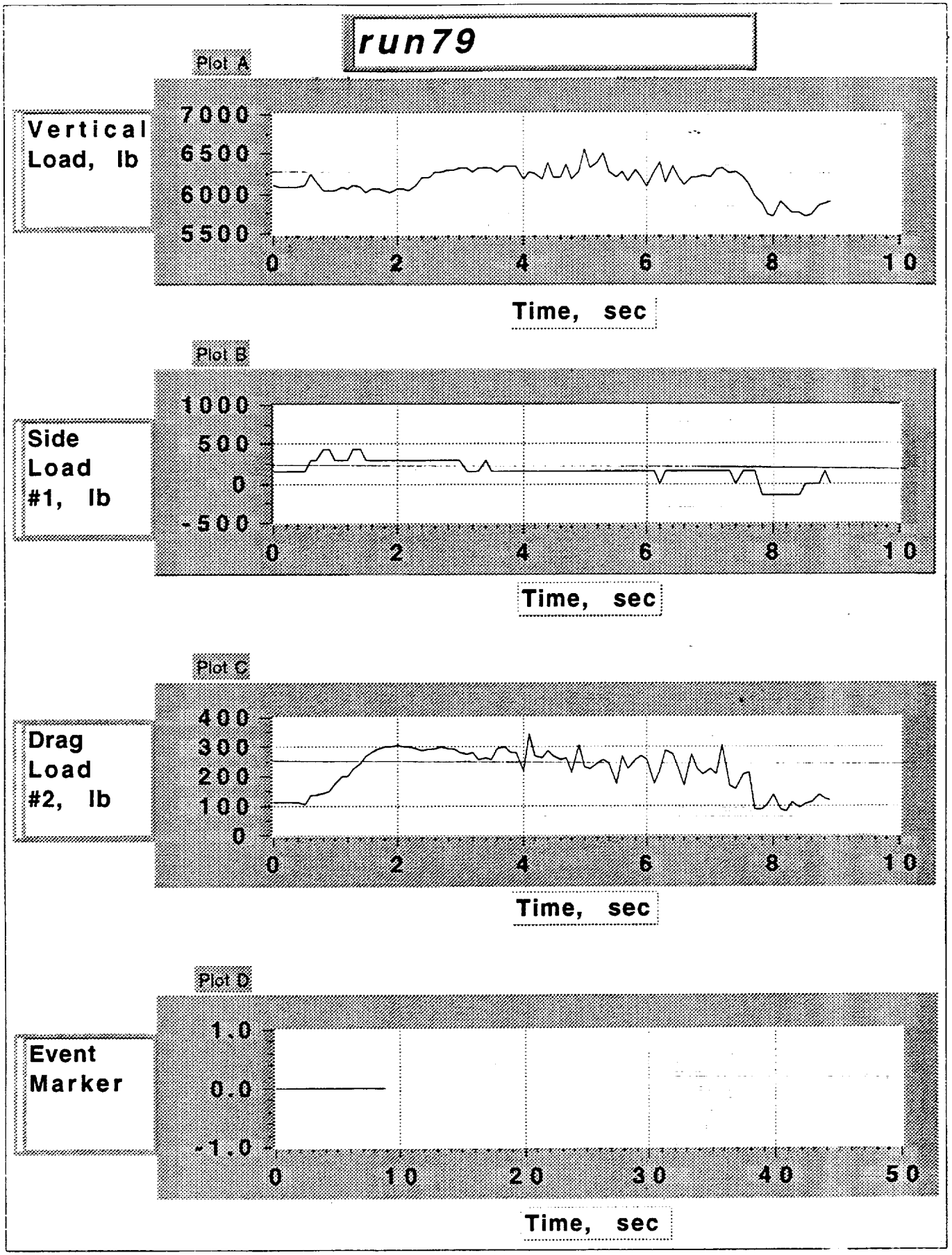

run74
Plot A
Vertical Load, lb
3600
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

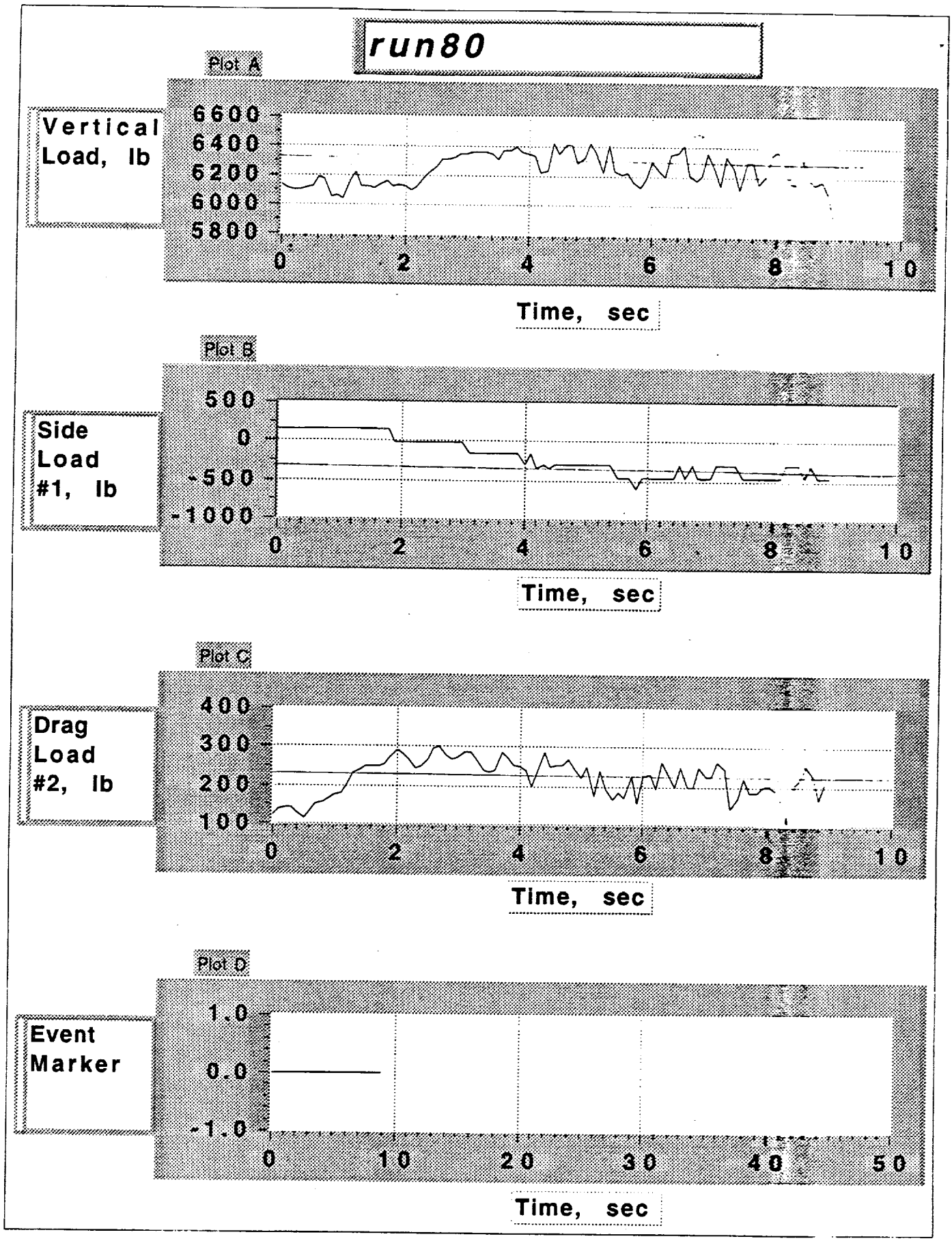

run75
Plot A
Vertical Load, lb
4000
3500
3000
2500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

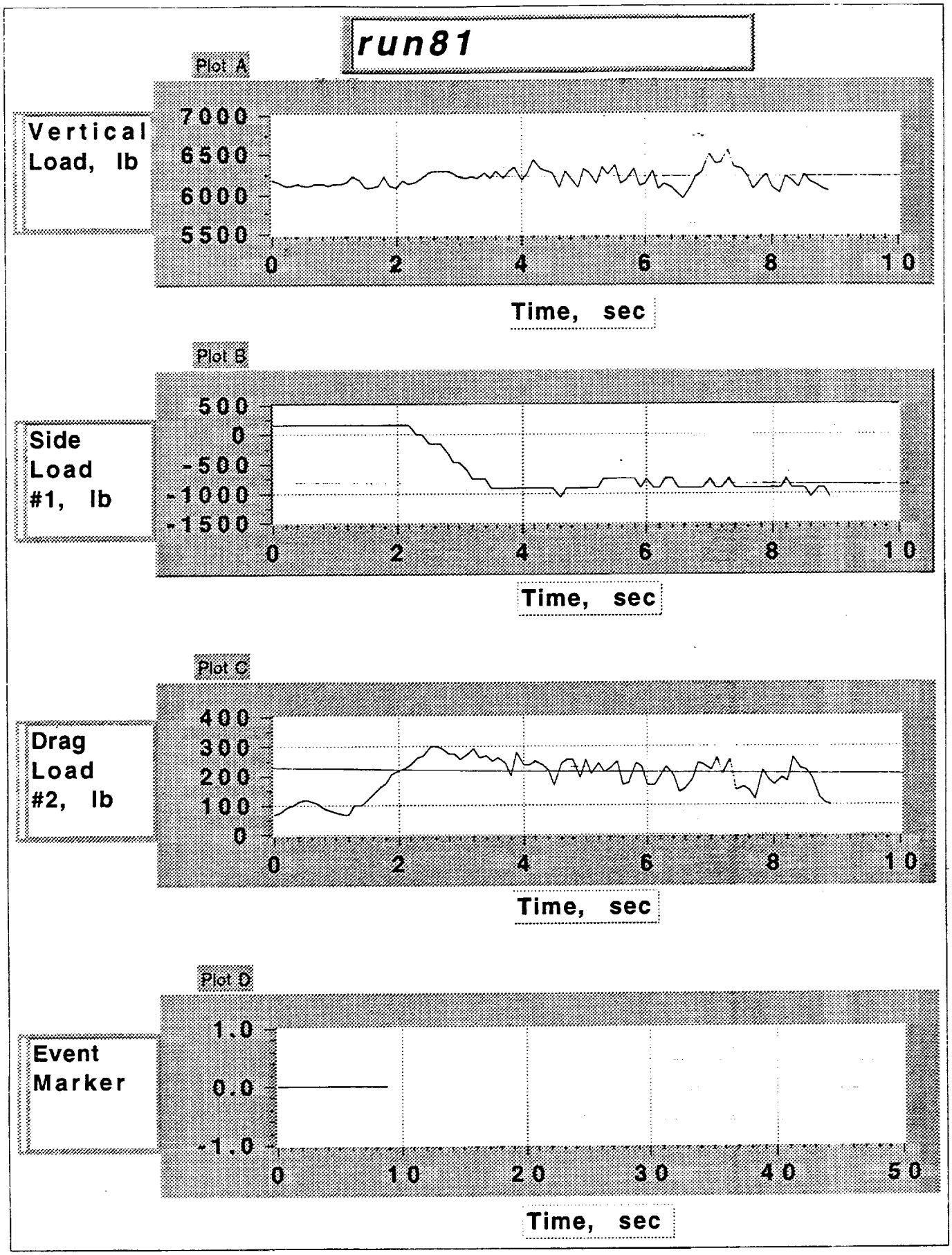

run76
Plot A
Vertical Load, lb
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

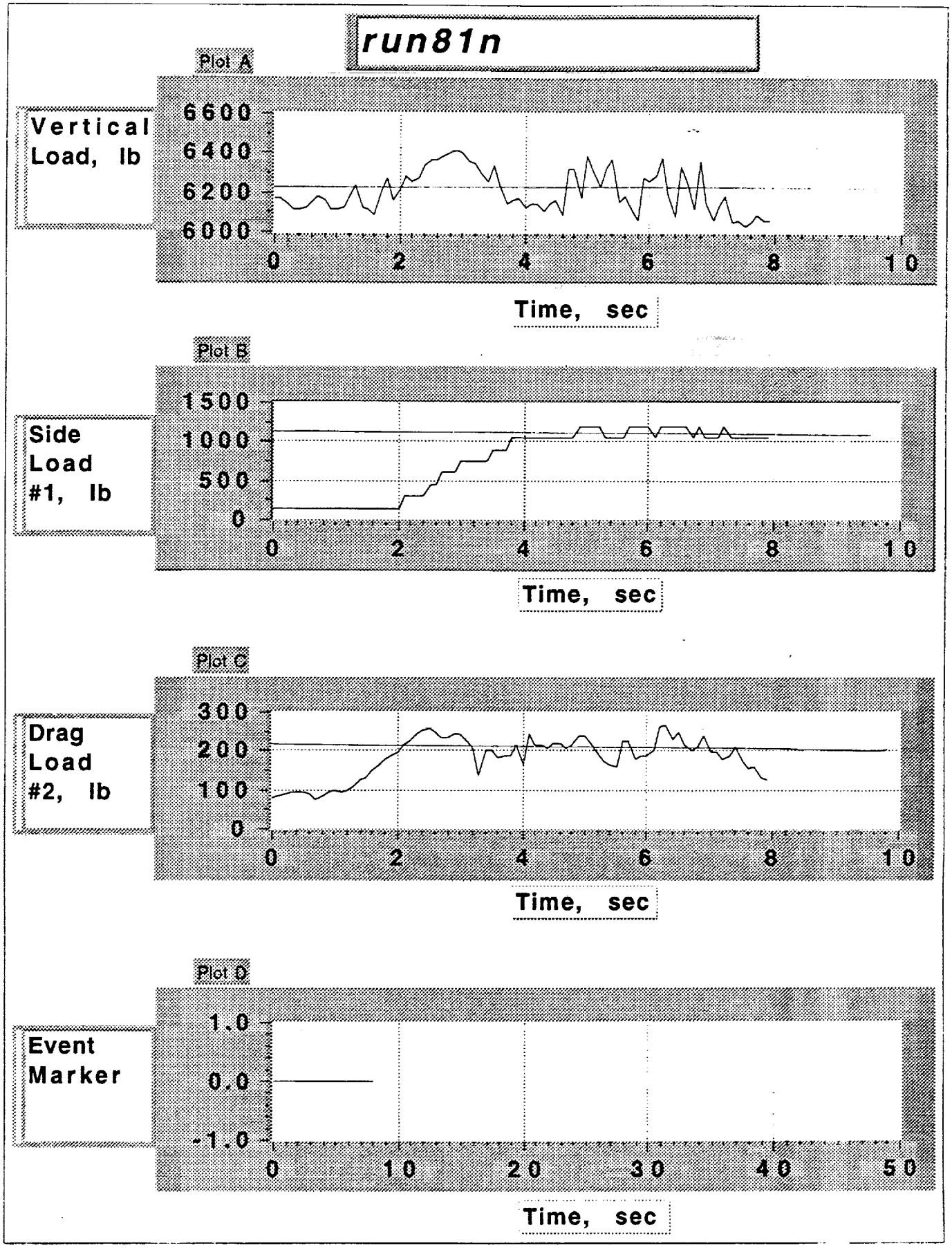

run77
Plot A
Vertical Load, lb
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
3000
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

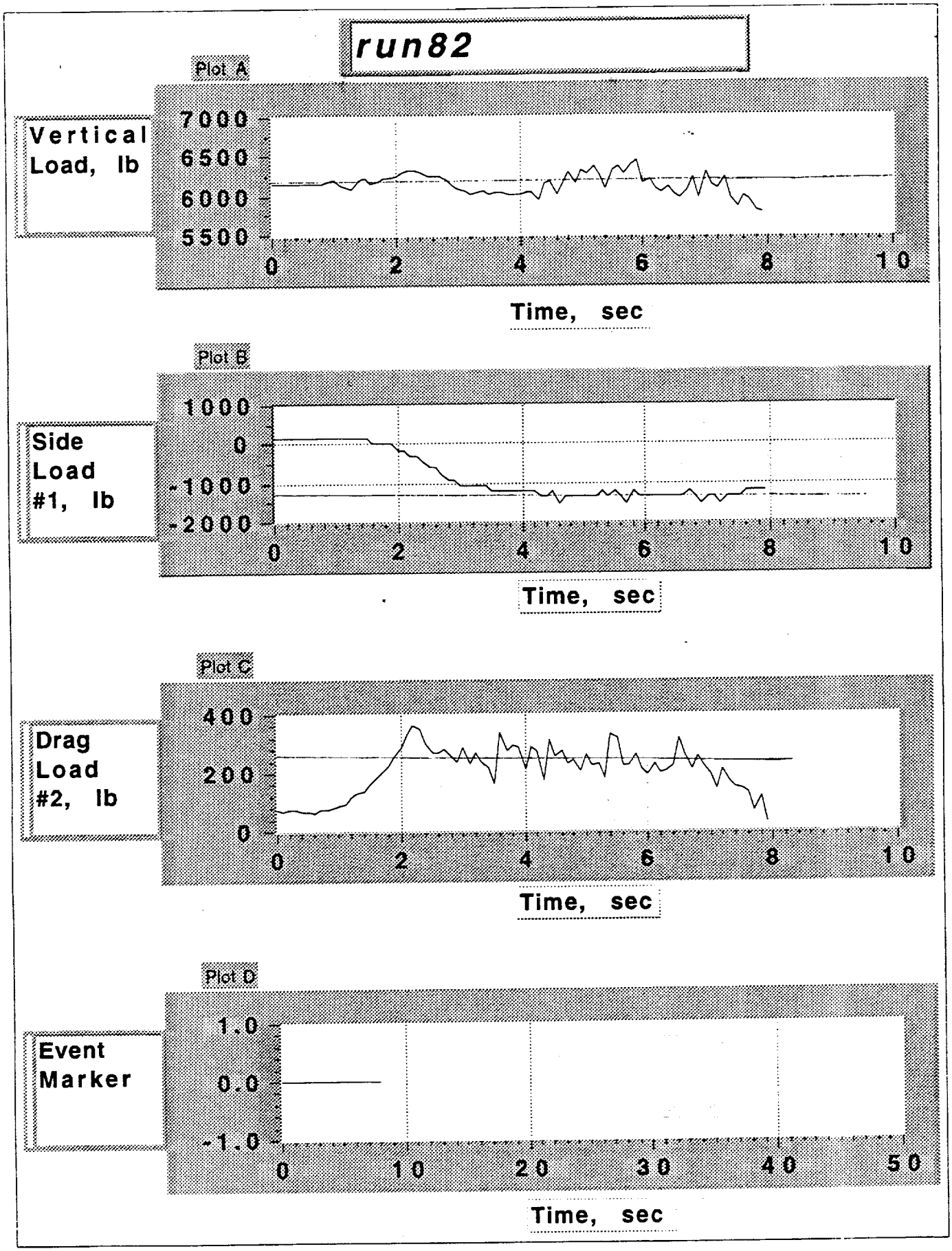

run78
Plot A
Vertical Load, lb
3600
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
3000
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

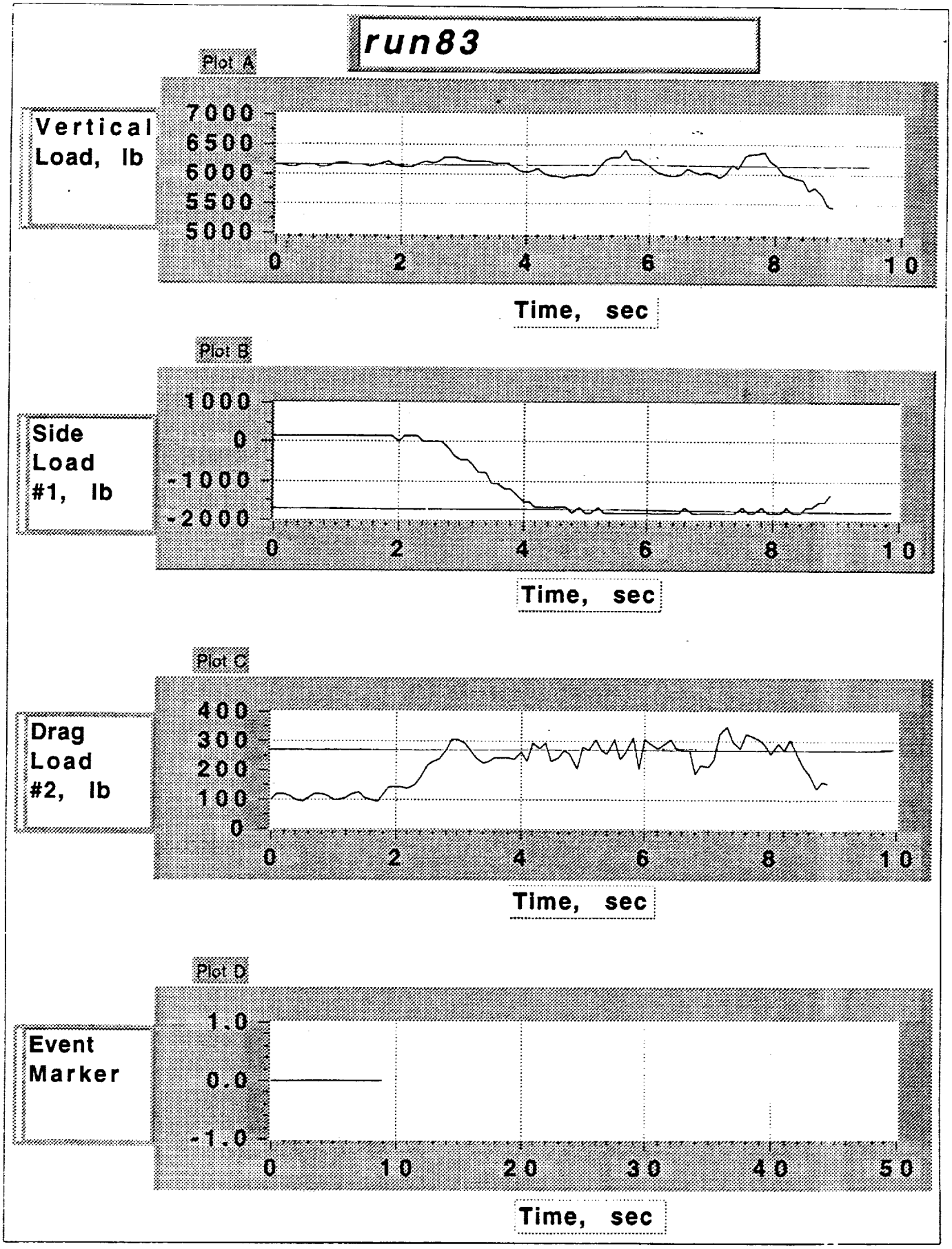

run79
Plot A
Vertical Load, lb
7000
6500
6000
5500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
300
200
100
0
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

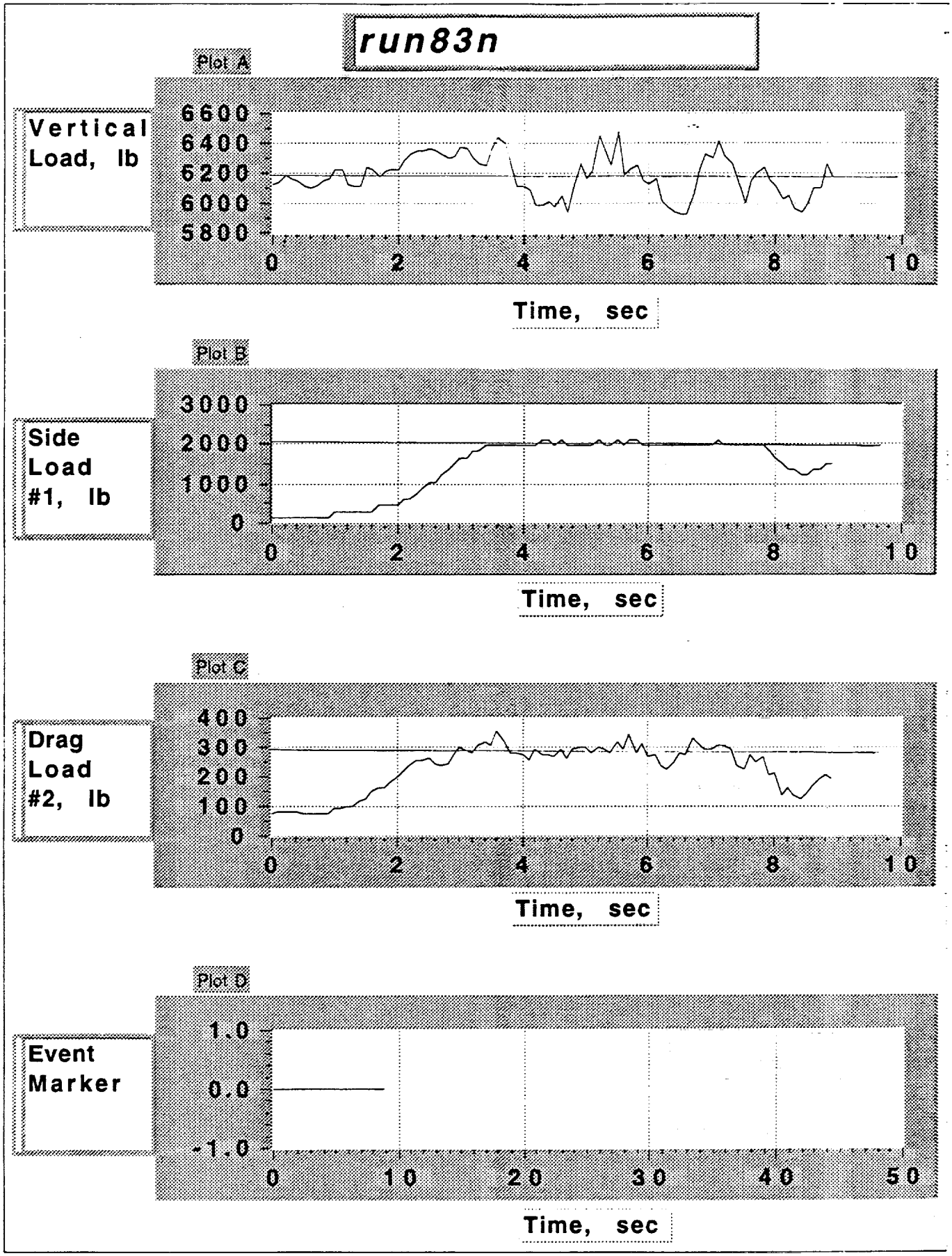

run80
Plot A
Vertical Load, lb
6600
6400
6200
6000
5800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
300
200
100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

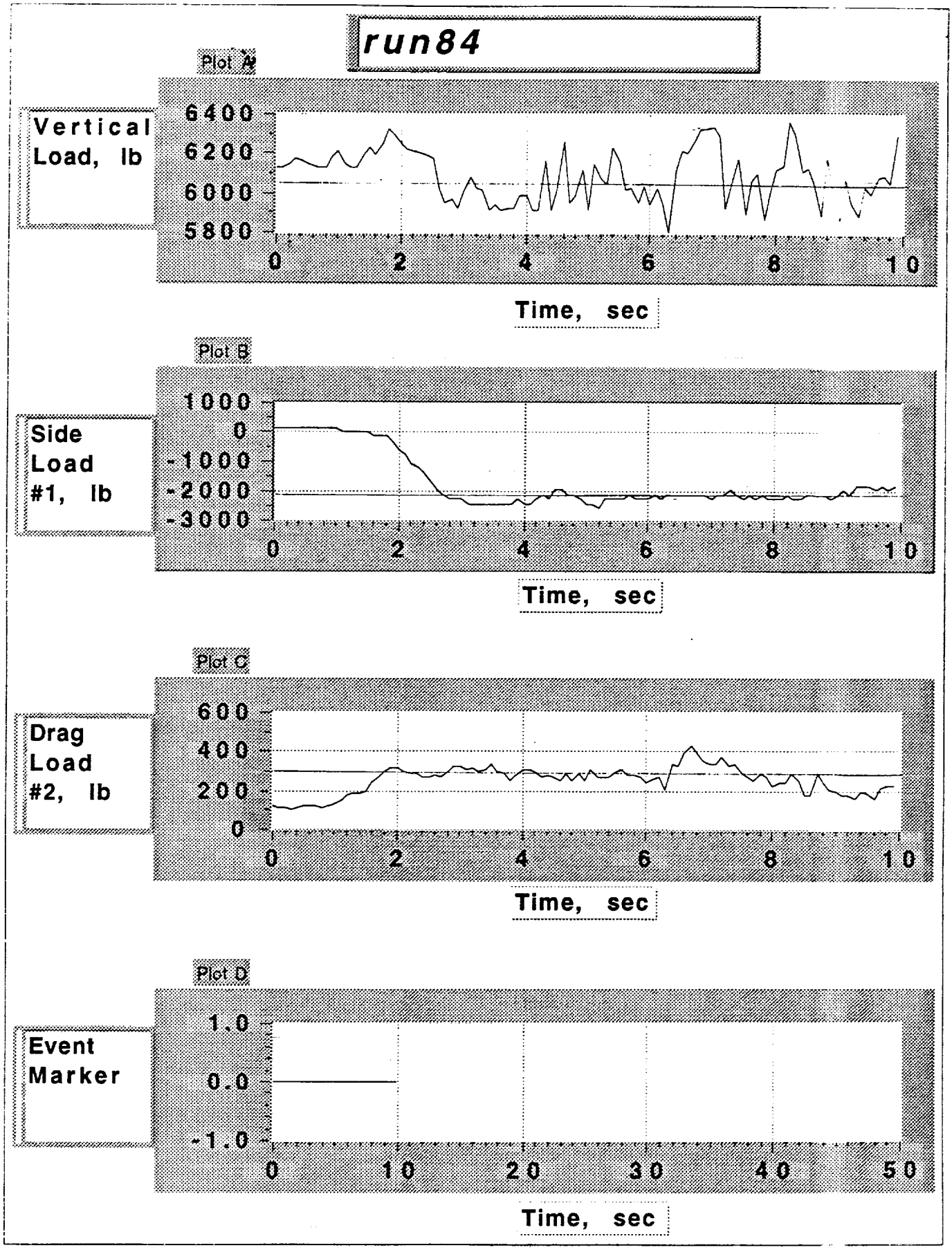

run81
Plot A
Vertical Load, lb
7000
6500
6000
5500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
-1500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
300
200
100
0
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

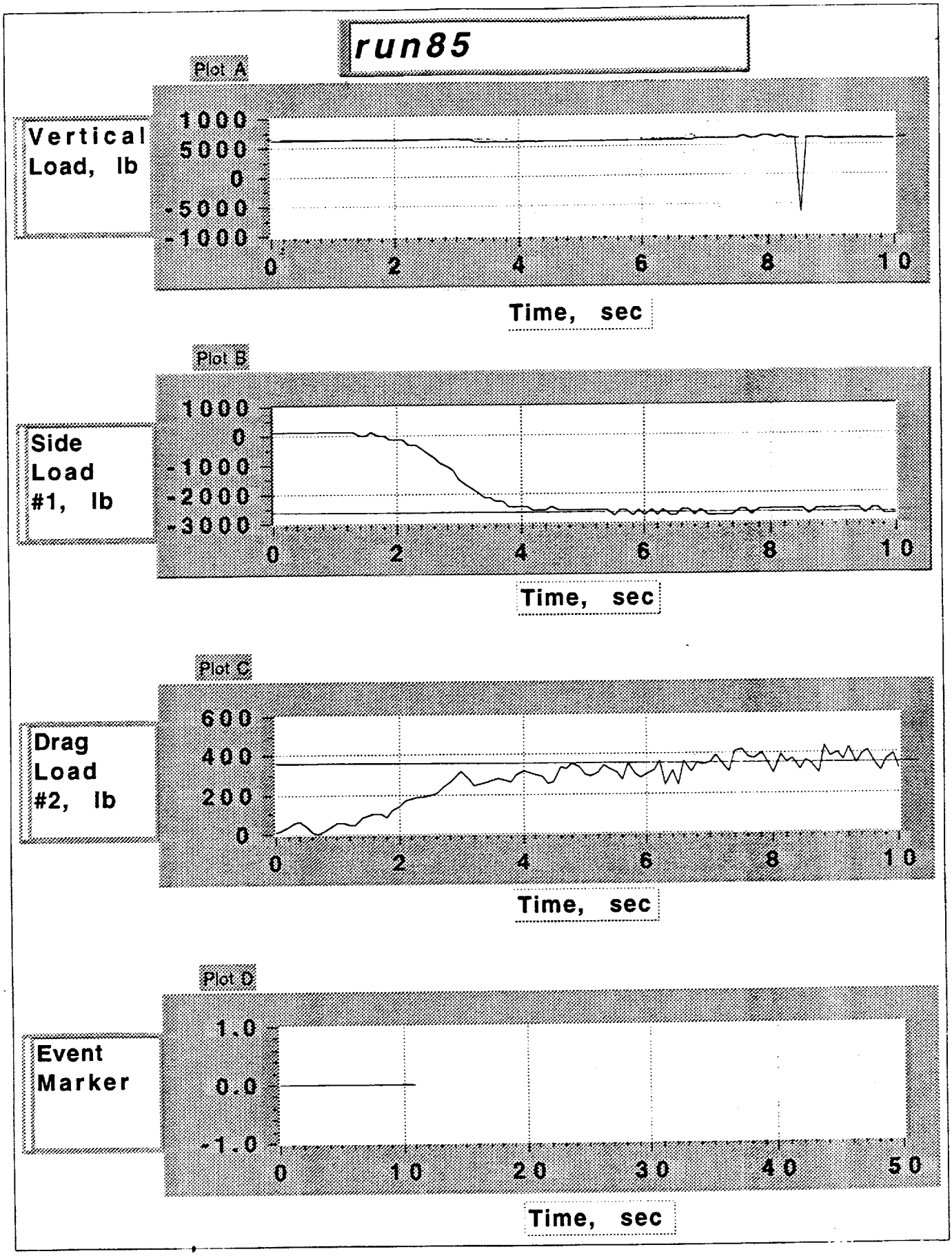

run81n
Plot A
Vertical Load, lb
6600
6400
6200
6000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
300
200
100
0
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

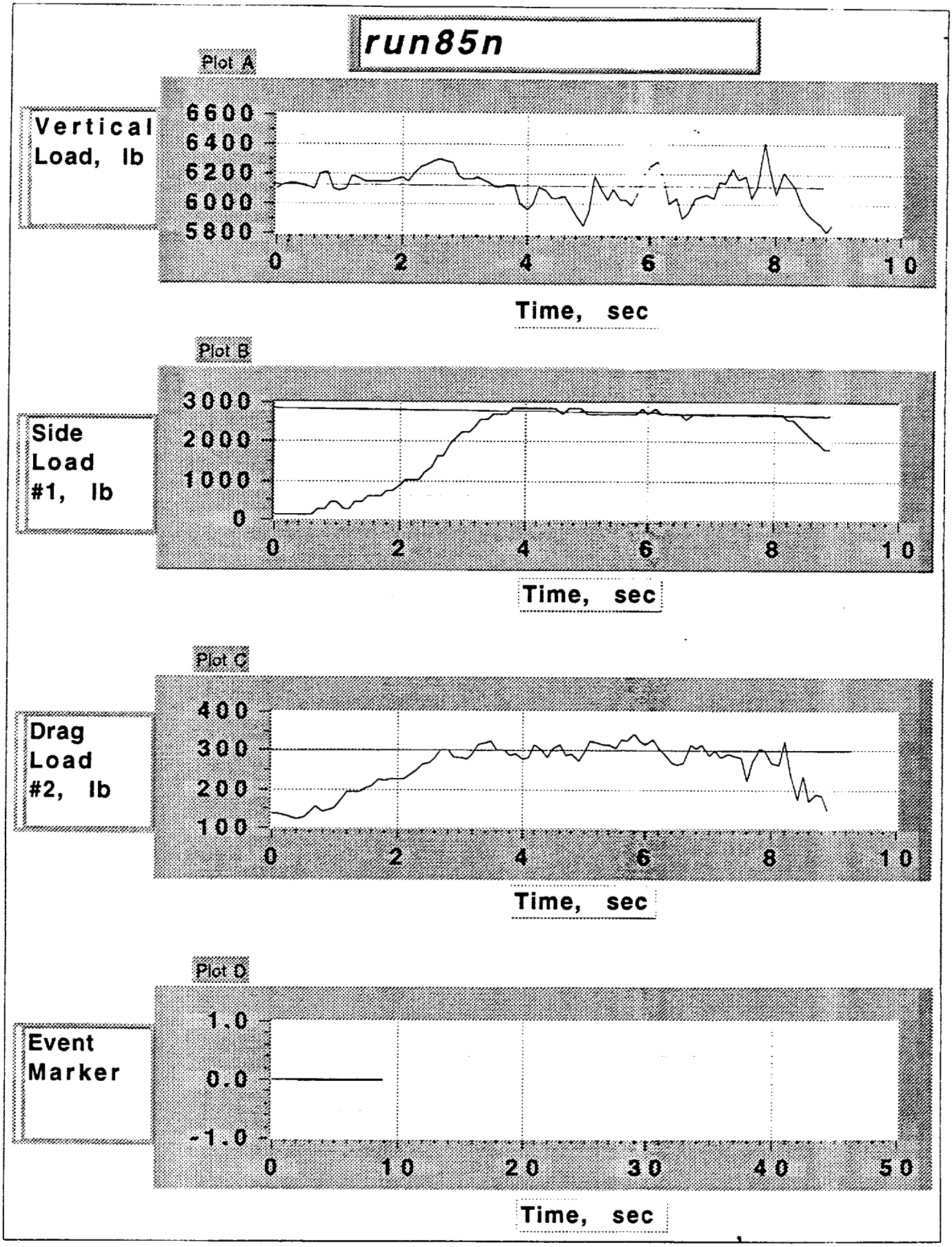

run82
Plot A
Vertical Load, lb
7000
6500
6000
5500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
200
0
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

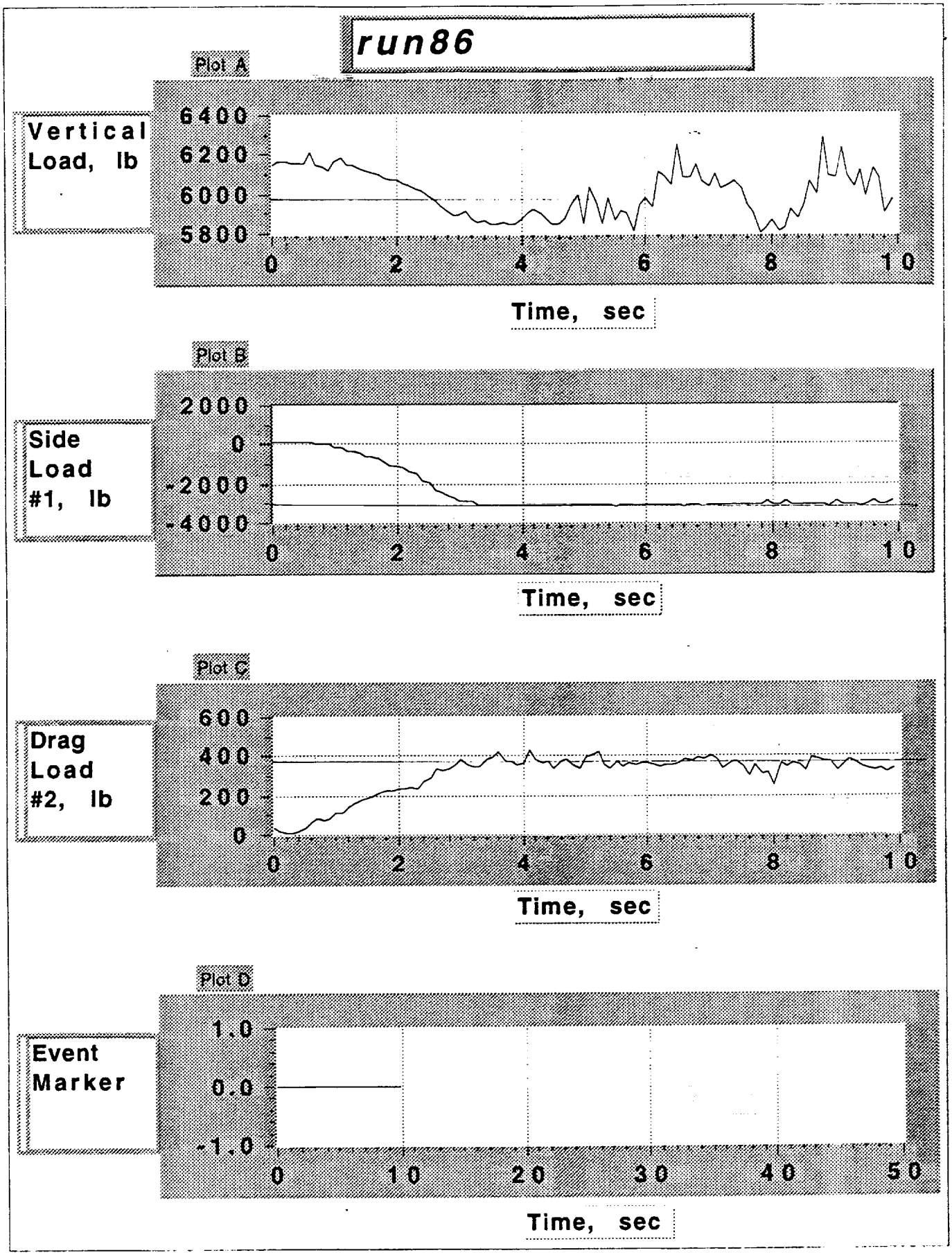

run83
Plot A
Vertical Load, lb
7000
6500
6000
5500
5000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
300
200
100
0
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

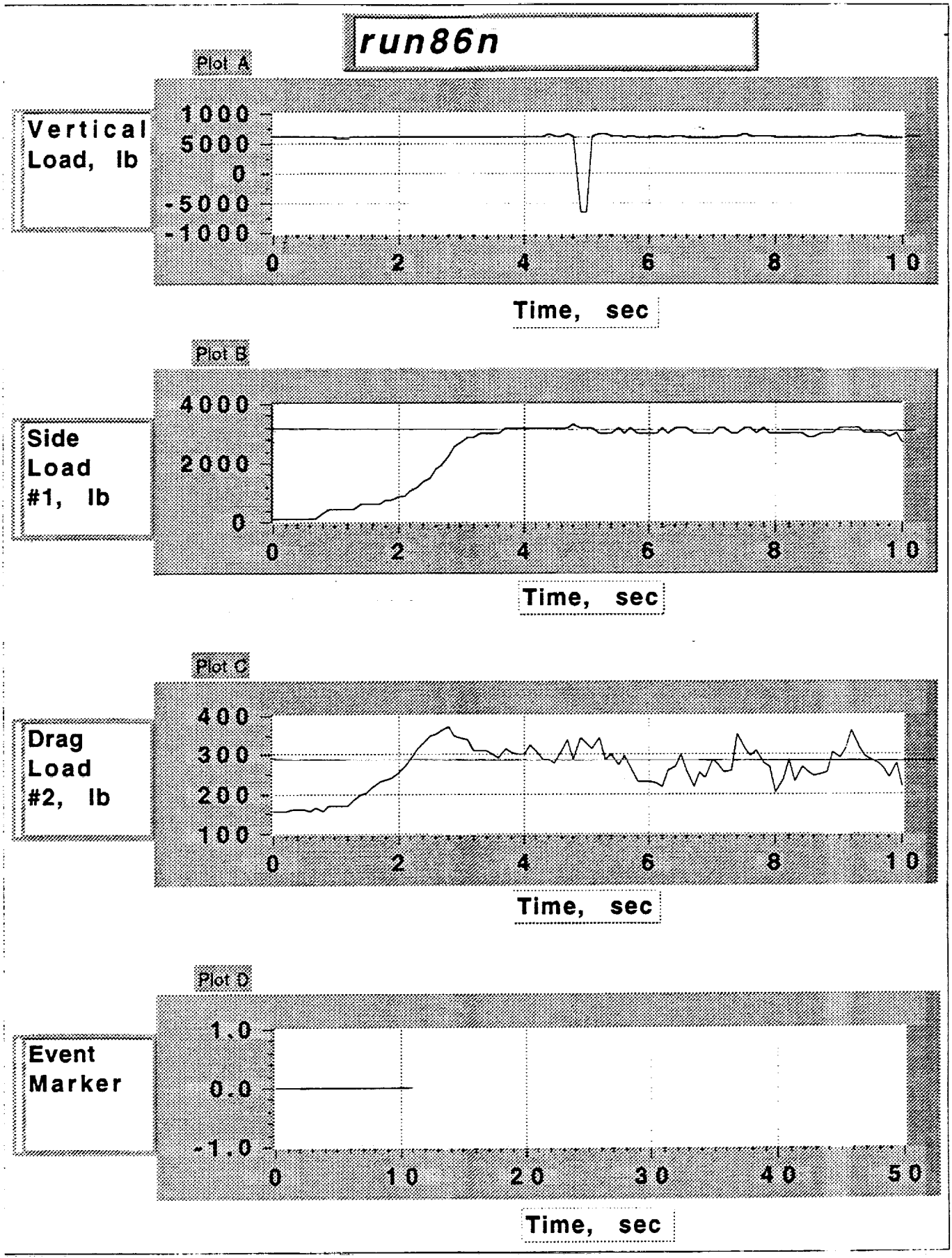

run83n
Plot A
Vertical Load, lb
6600
6400
6200
6000
5800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
3000
2000
1000
0
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
300
200
100
0
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

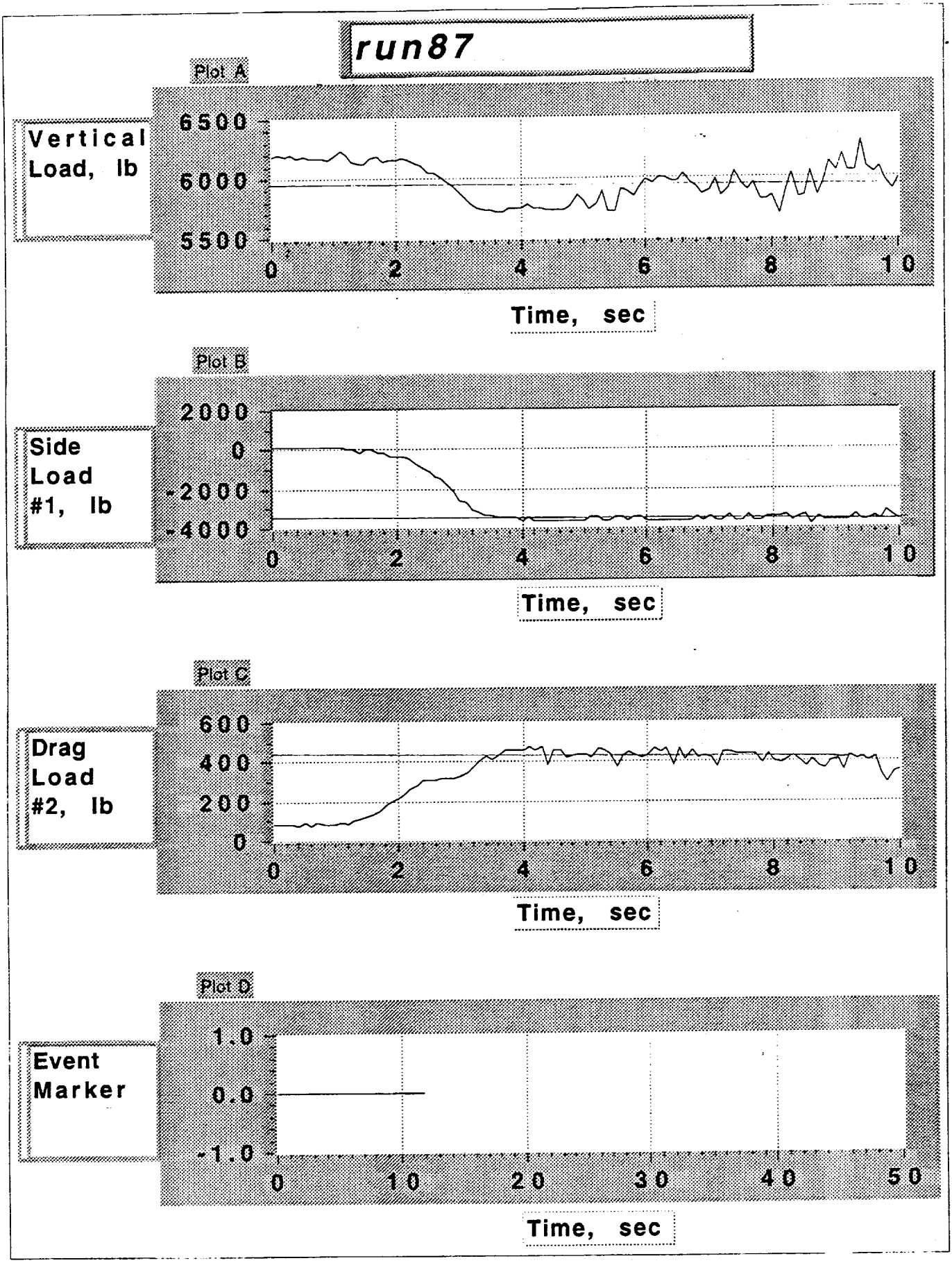

run84
Plot A
Vertical Load, lb
6400
6200
6000
5800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
-3000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

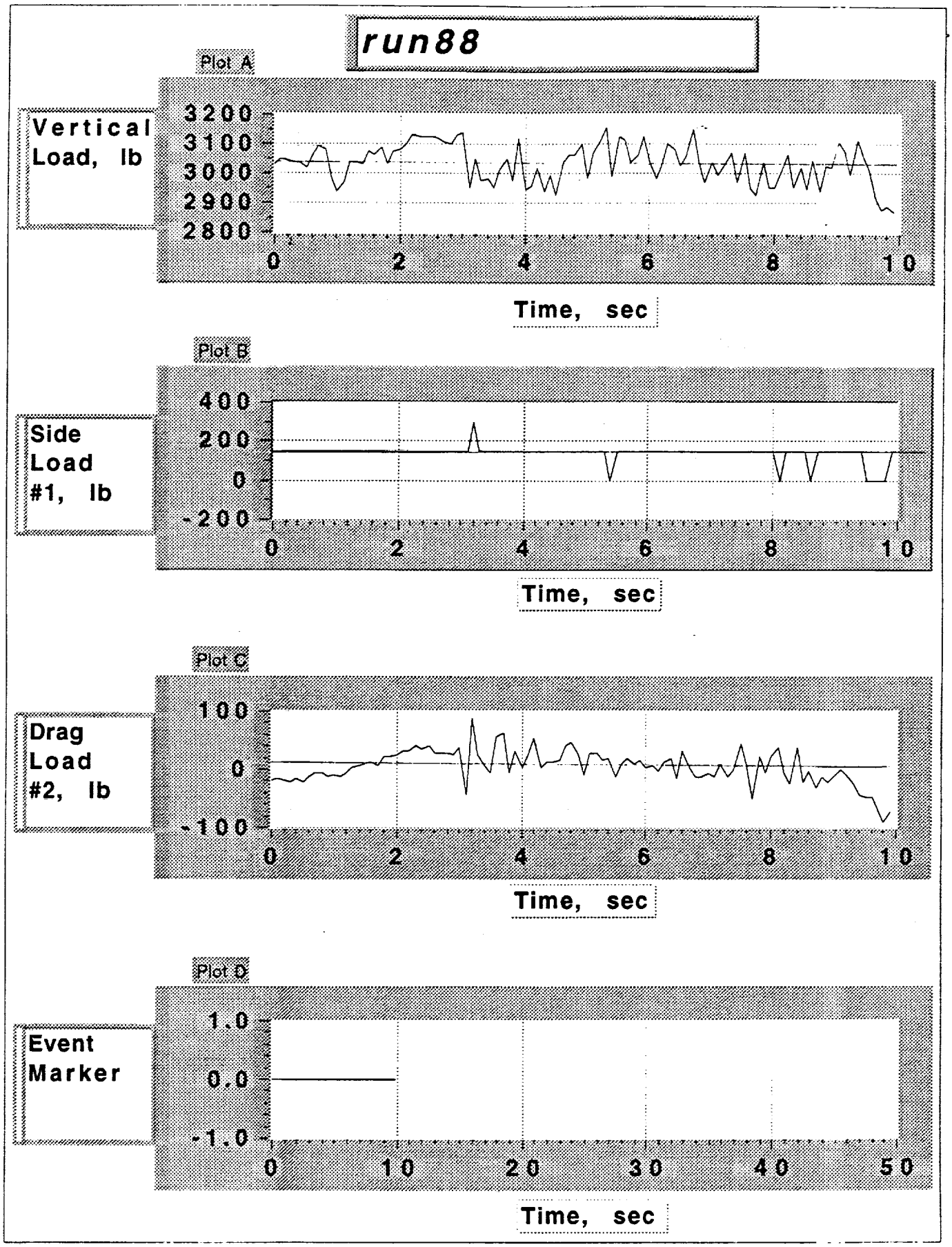

run85
Plot A
Vertical Load, lb
1000
5000
0
-5000
-1000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
-3000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

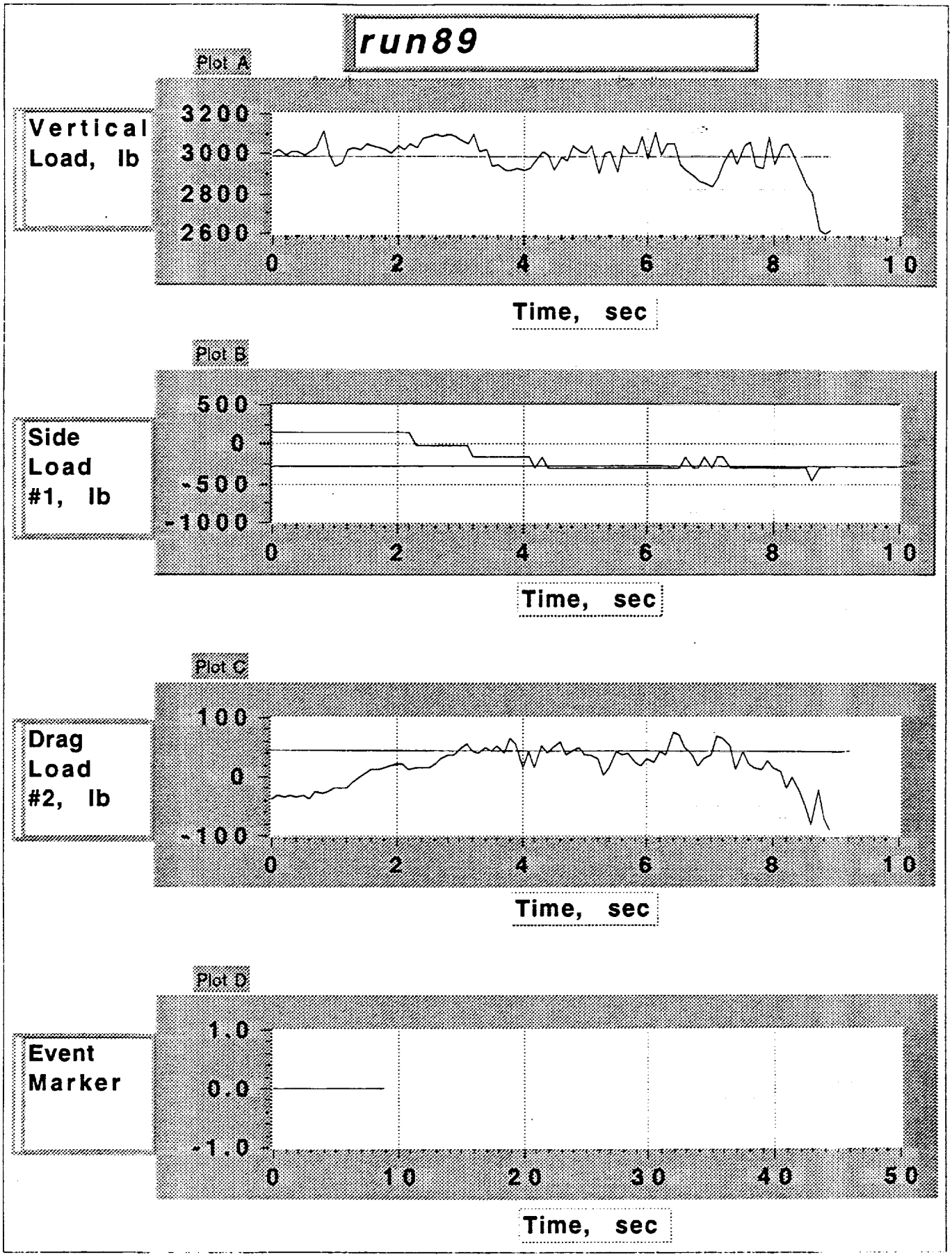

run85n
Plot A
Vertical Load, lb
6600
6400
6200
6000
5800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
3000
2000
1000
0
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
300
200
100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

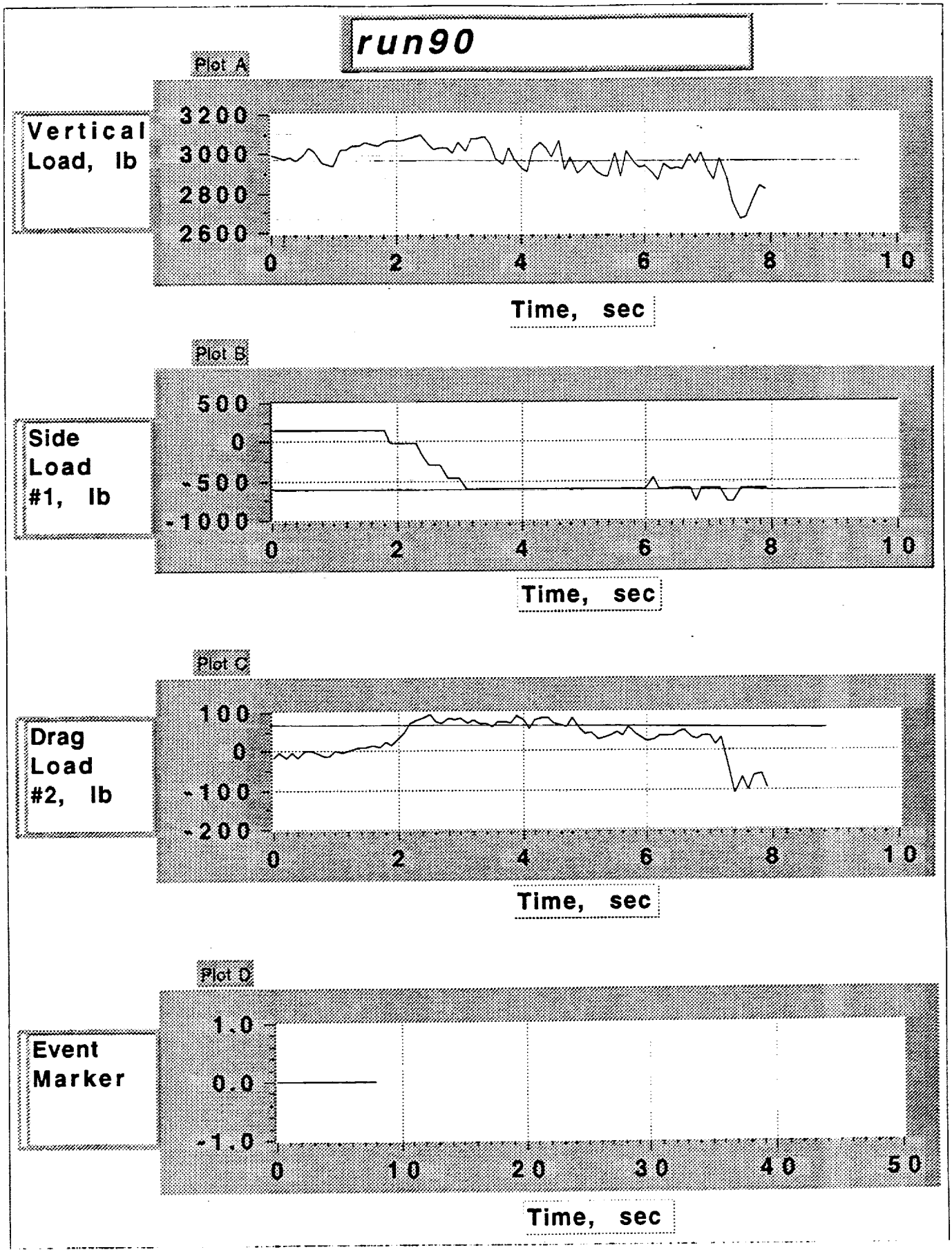

run86
Plot A
Vertical Load, lb
6400
6200
6000
5800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
2000
0
-2000
-4000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

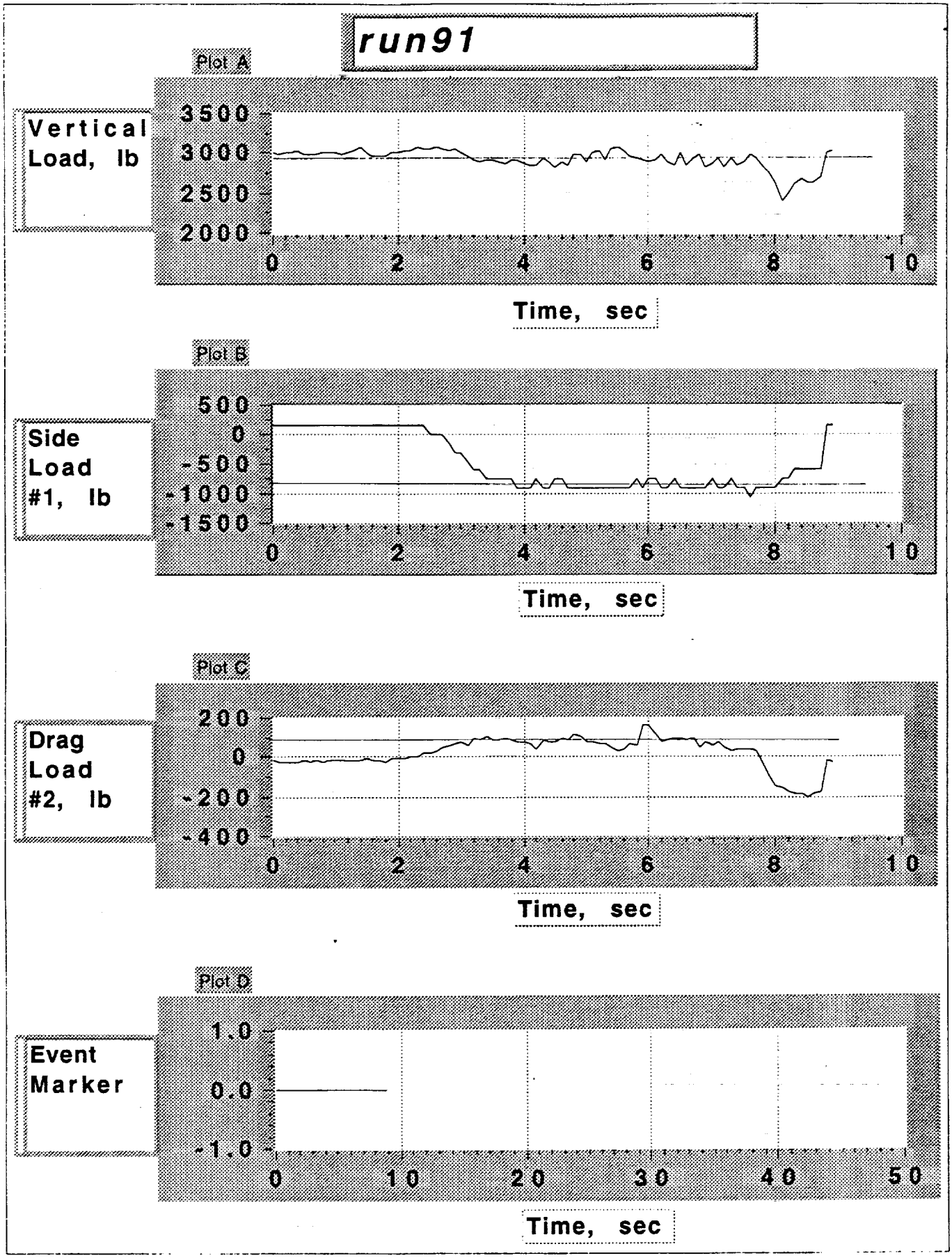

run86n
Plot A
Vertical Load, lb
1000
5000
0
-5000
-1000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
4000
2000
0
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
300
200
100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

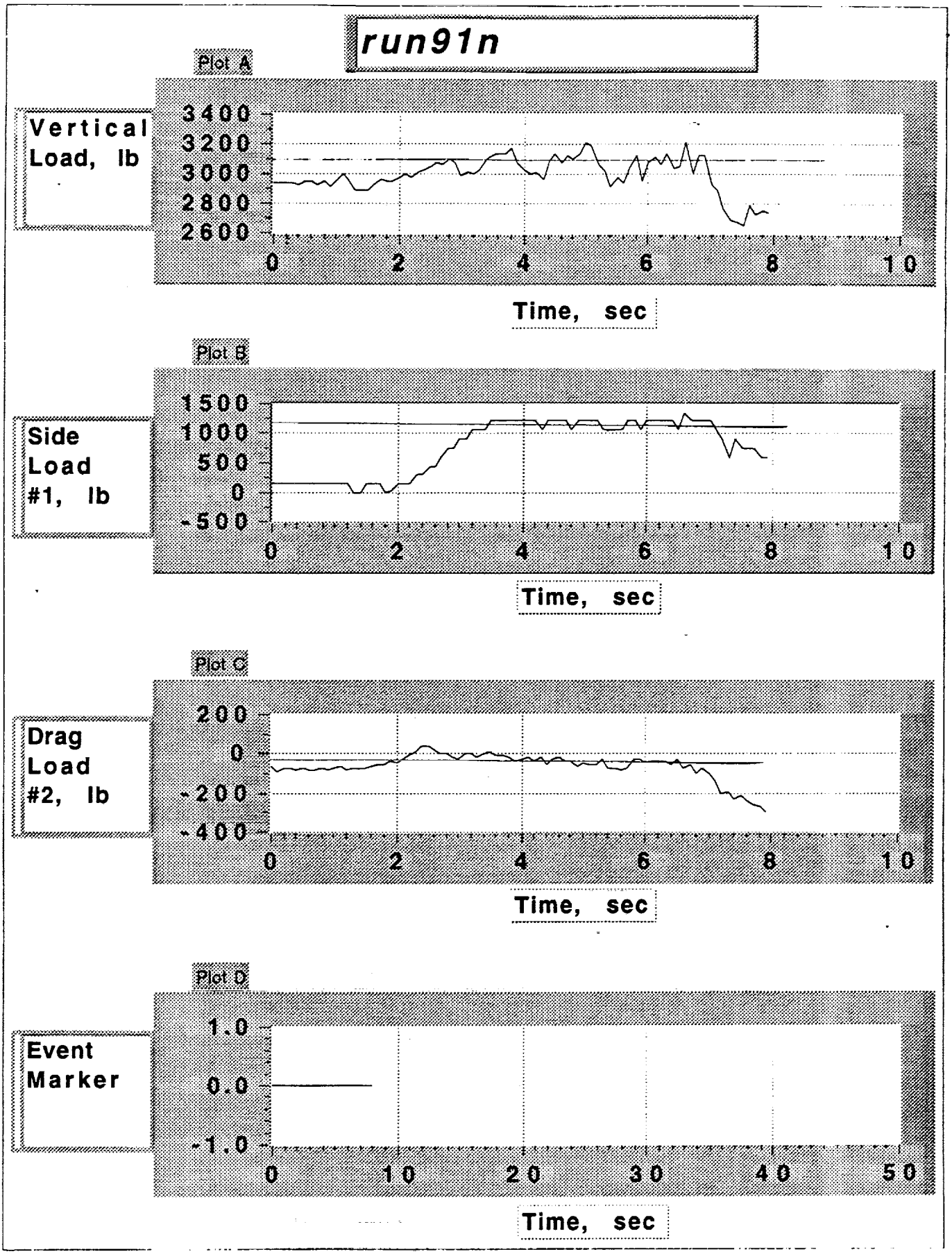

run87
Plot A
Vertical Load, lb
6500
6000
5500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
2000
0
-2000
-4000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
600
400
200
0
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

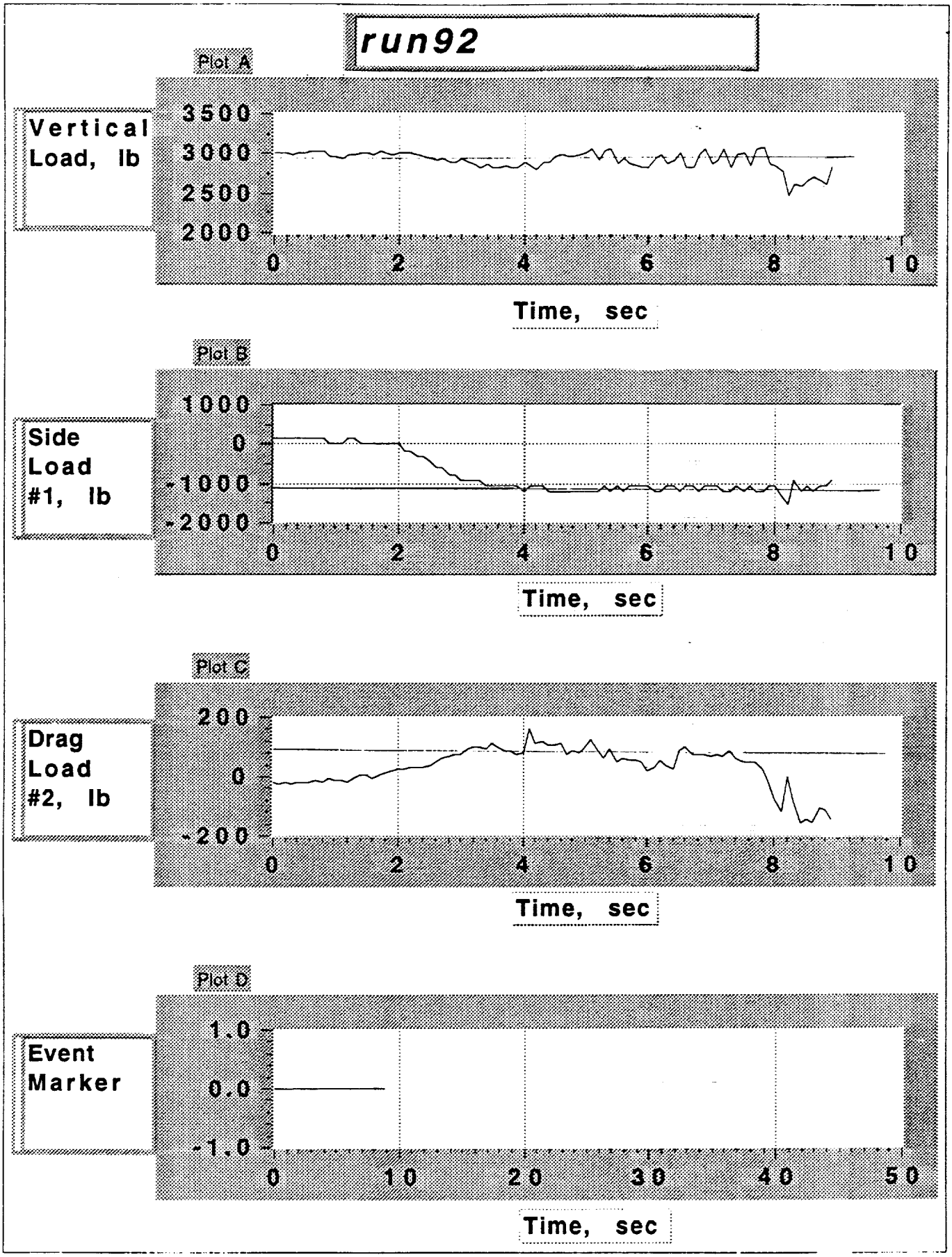

run88
Plot A
Vertical Load, lb
3200
3100
3000
2900
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

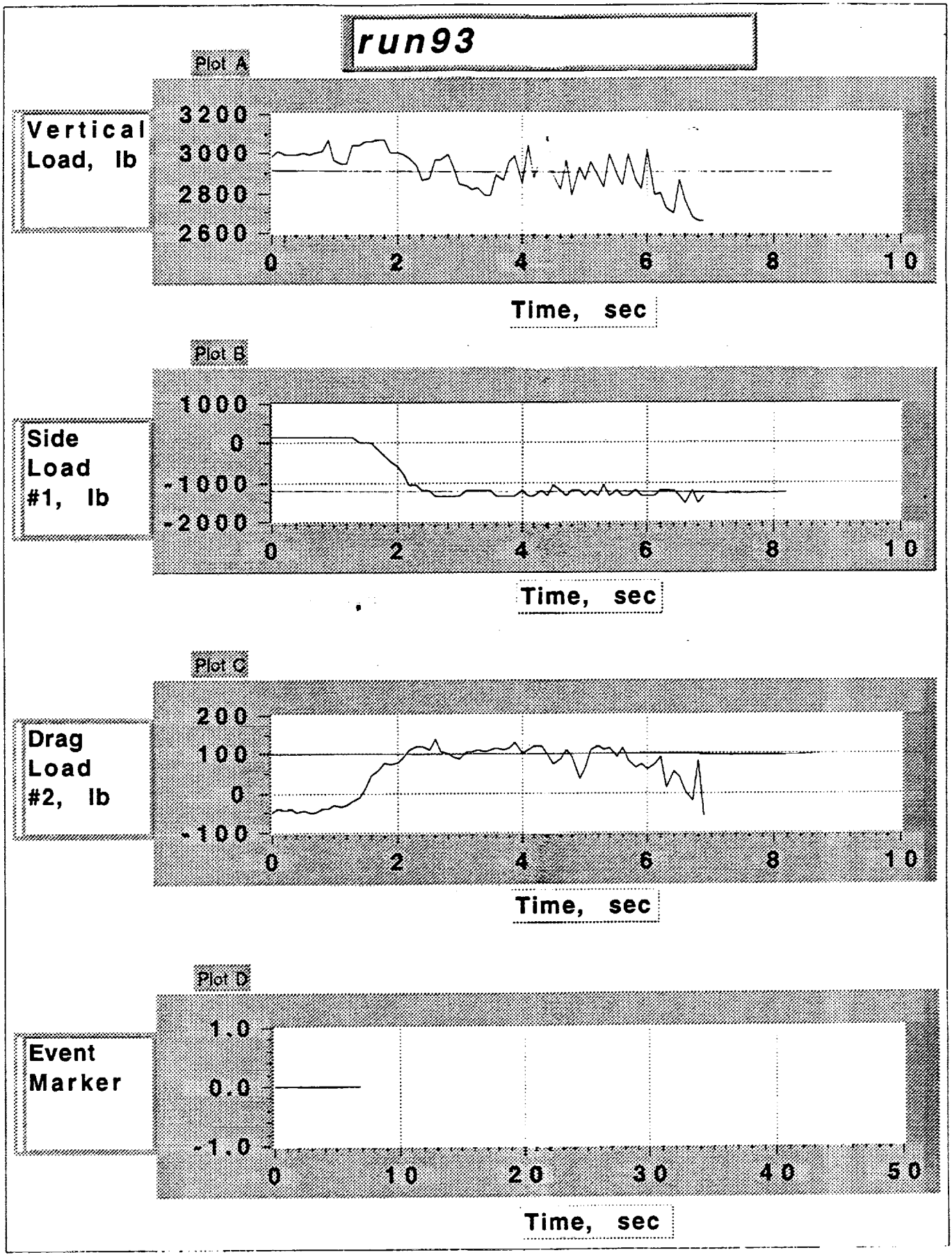

run89
Plot A
Vertical Load, lb
3200
3000
2800
2600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

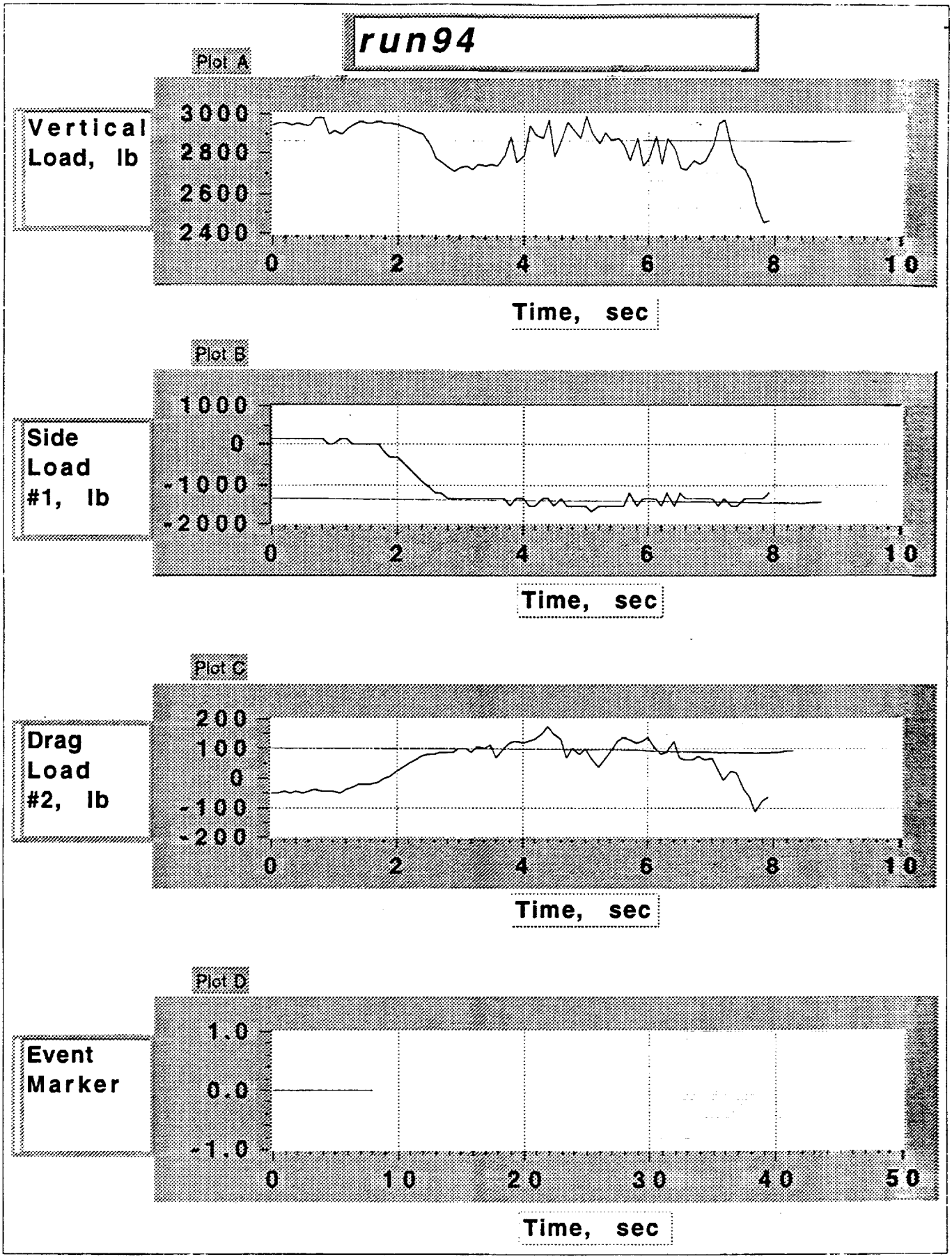

run90
Plot A
Vertical Load, lb
3200
3000
2800
2600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

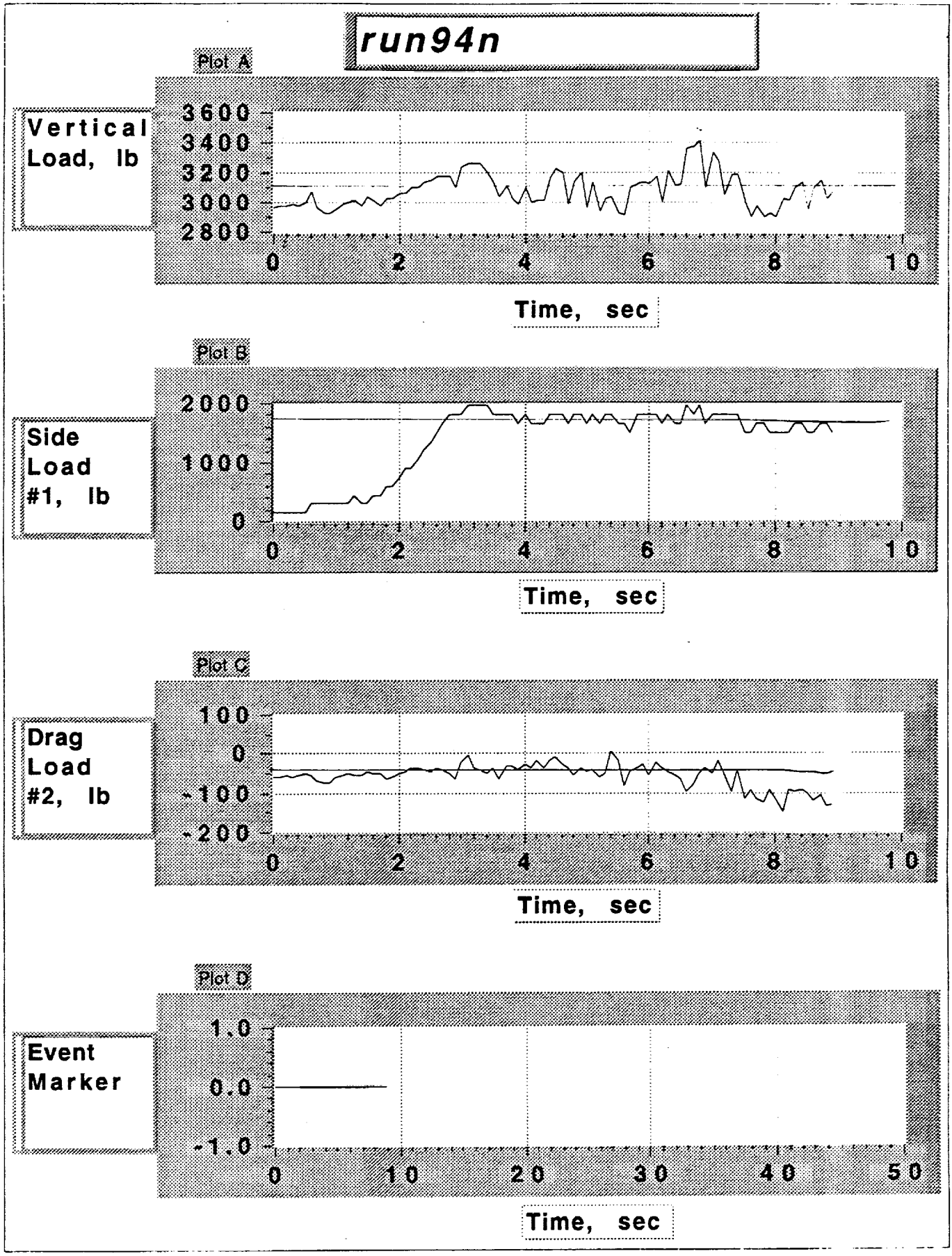

run91
Plot A
Vertical Load, lb
3500
3000
2500
2000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
-1500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

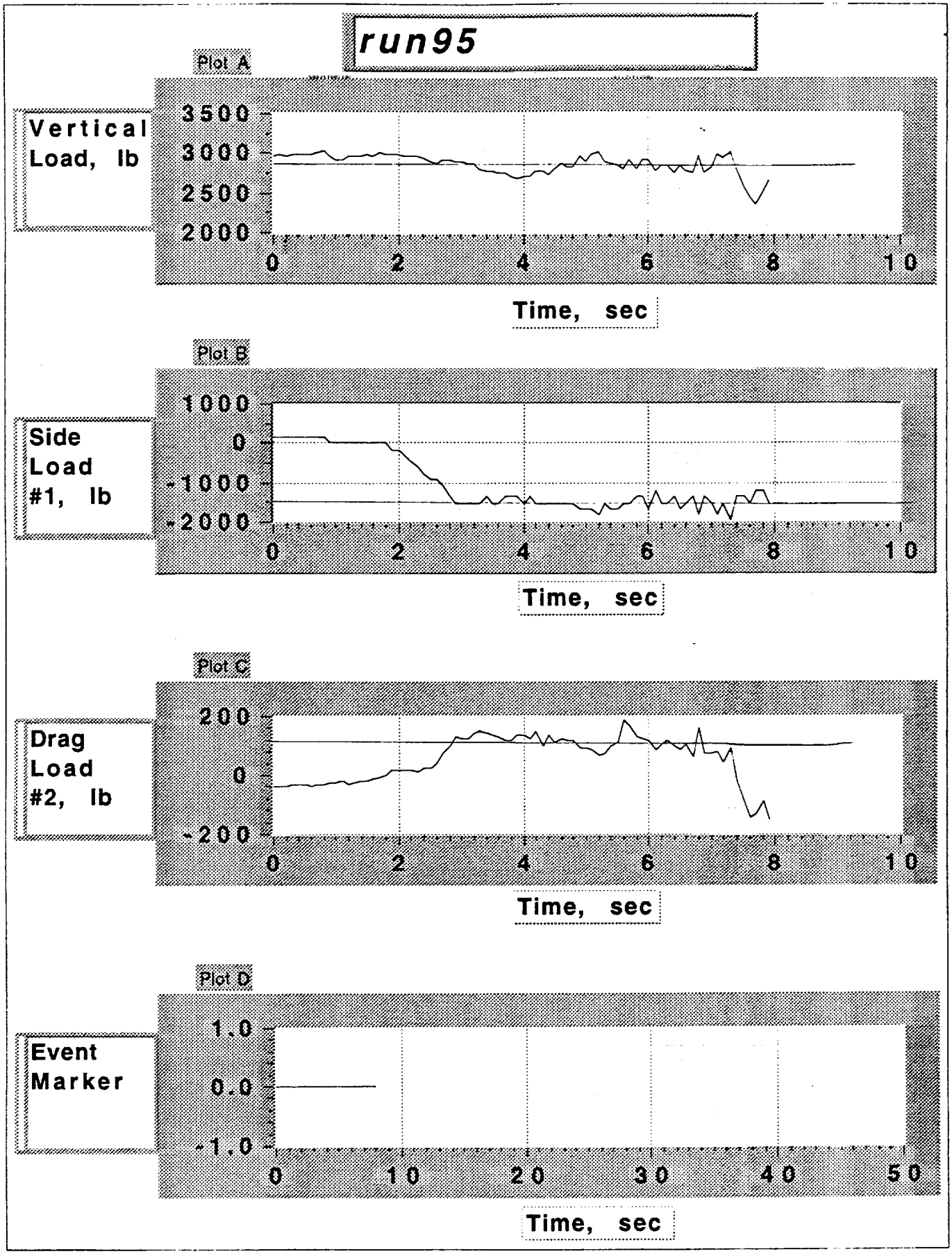

run91n
Plot A
Vertical Load, lb
3400
3200
3000
2800
2600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1500
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

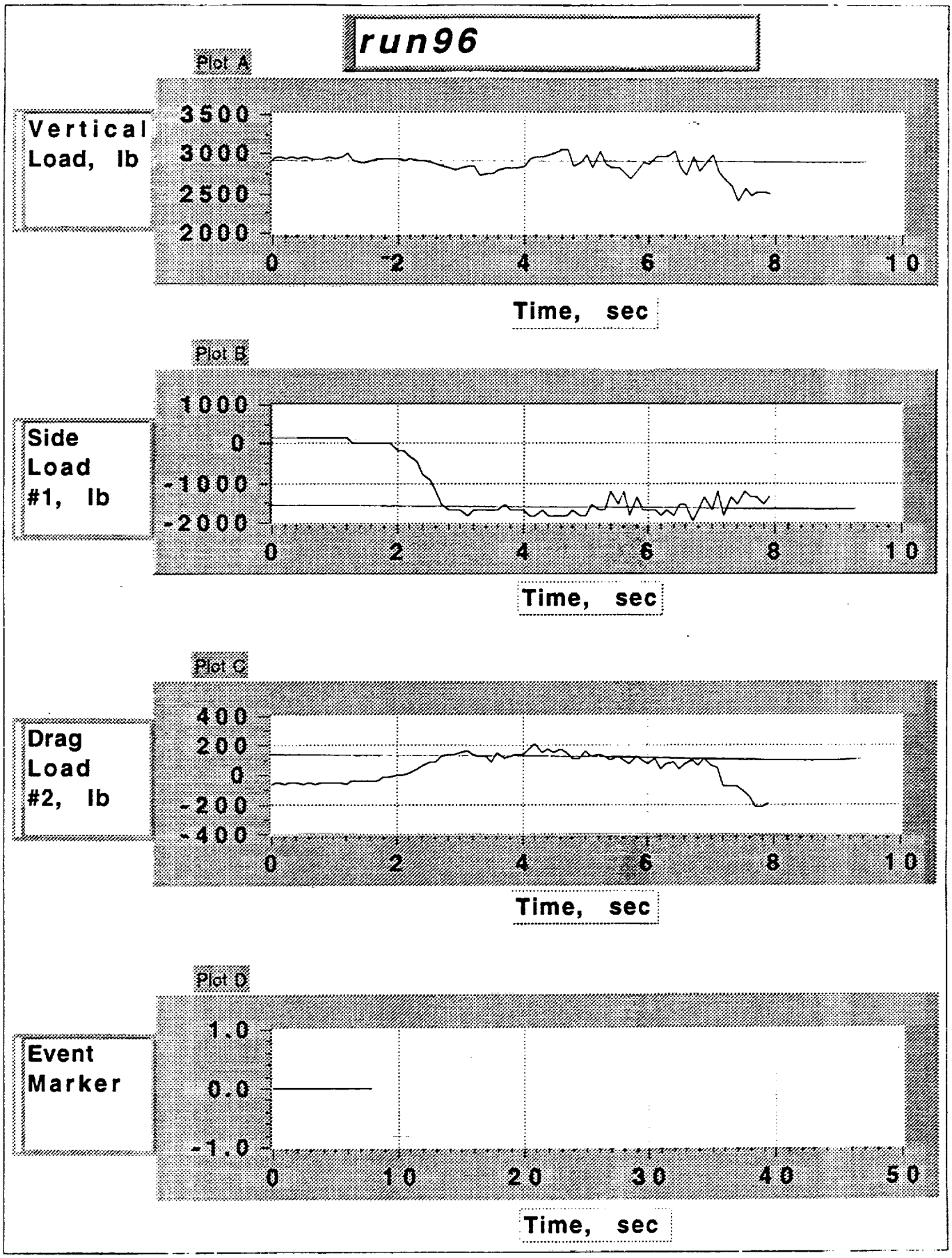

run92
Plot A
Vertical Load, lb
3500
3000
2500
2000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

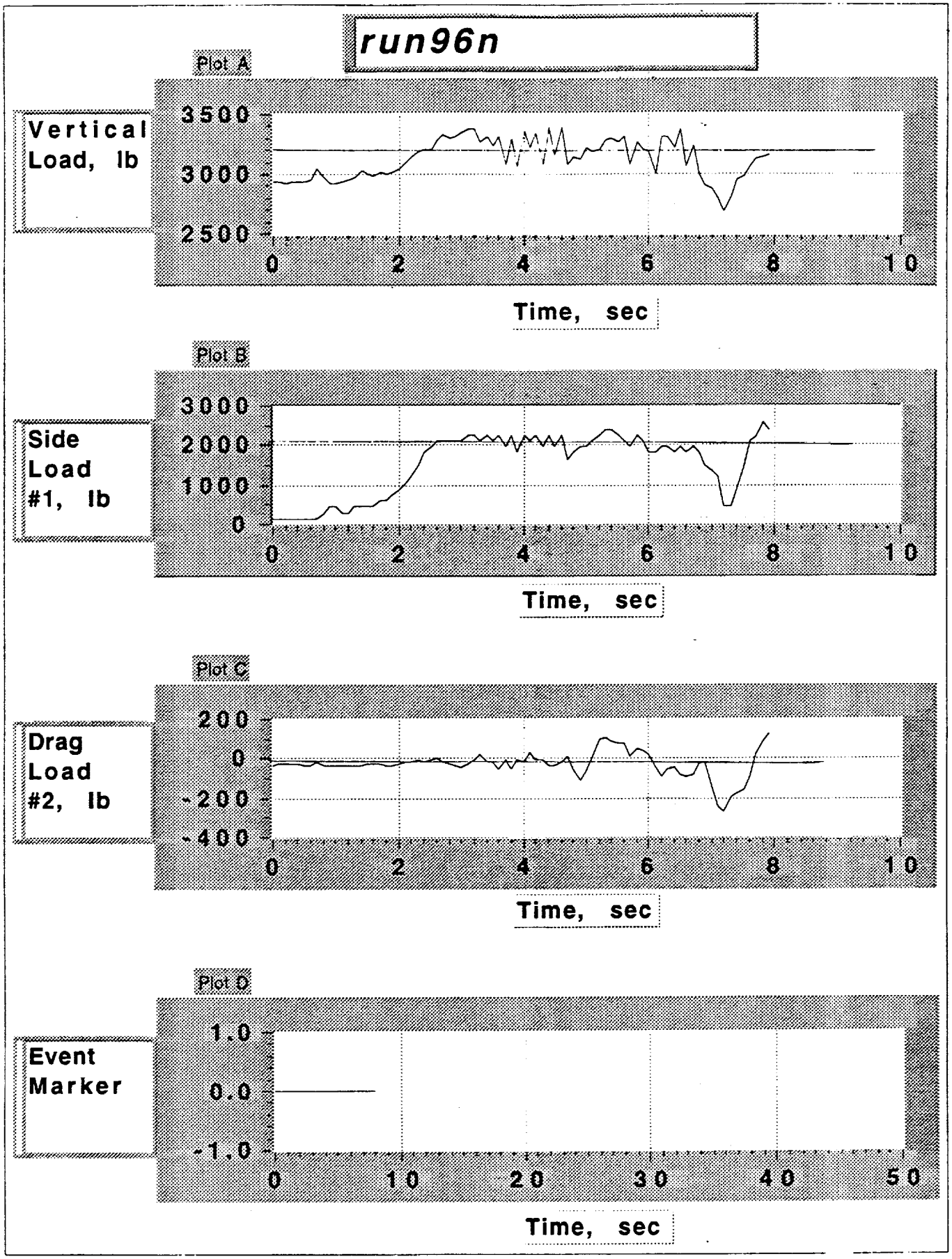

run93
Plot A
Vertical Load, lb
3200
3000
2800
2600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

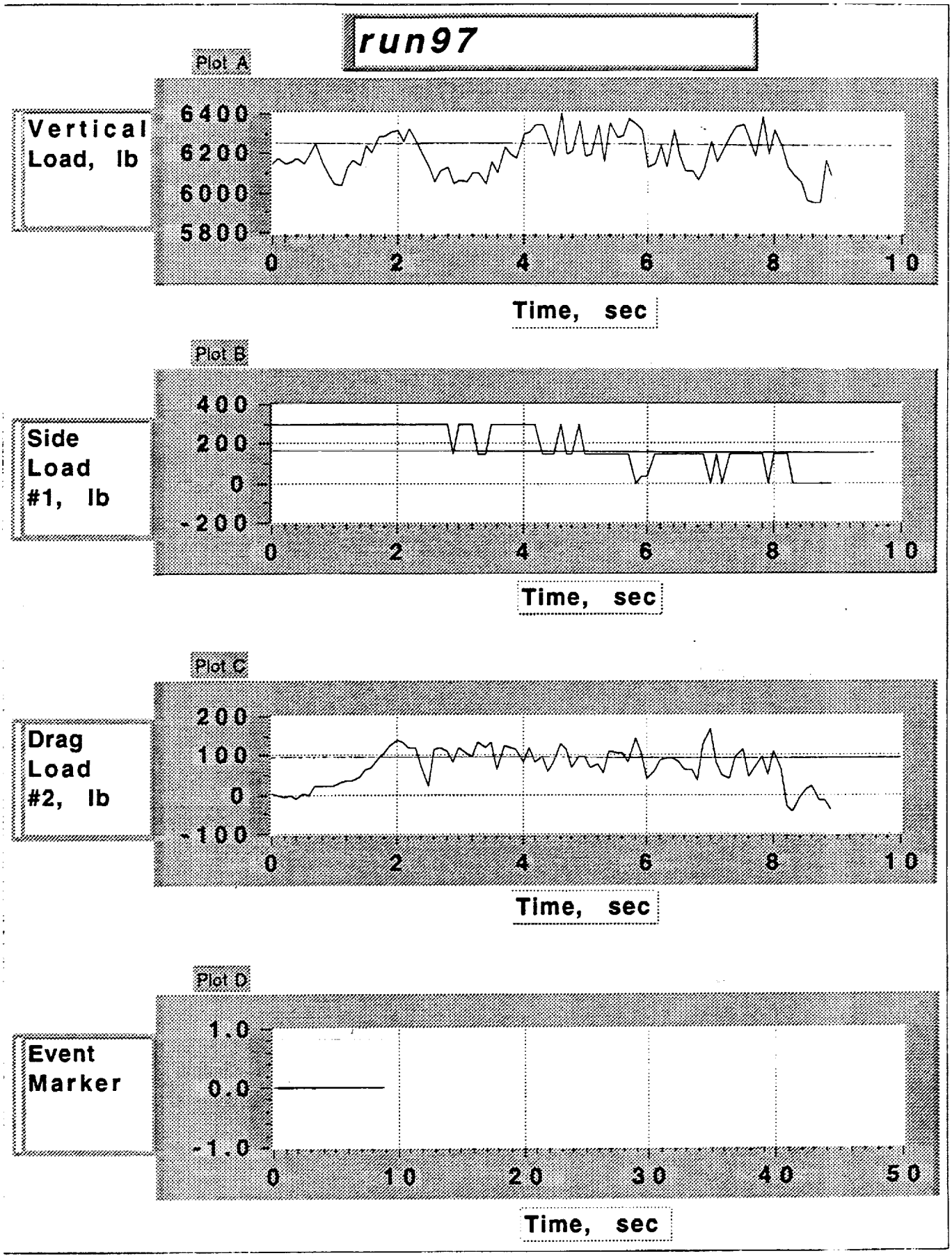

run94
Plot A
Vertical Load, lb
3000
2800
2600
2400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

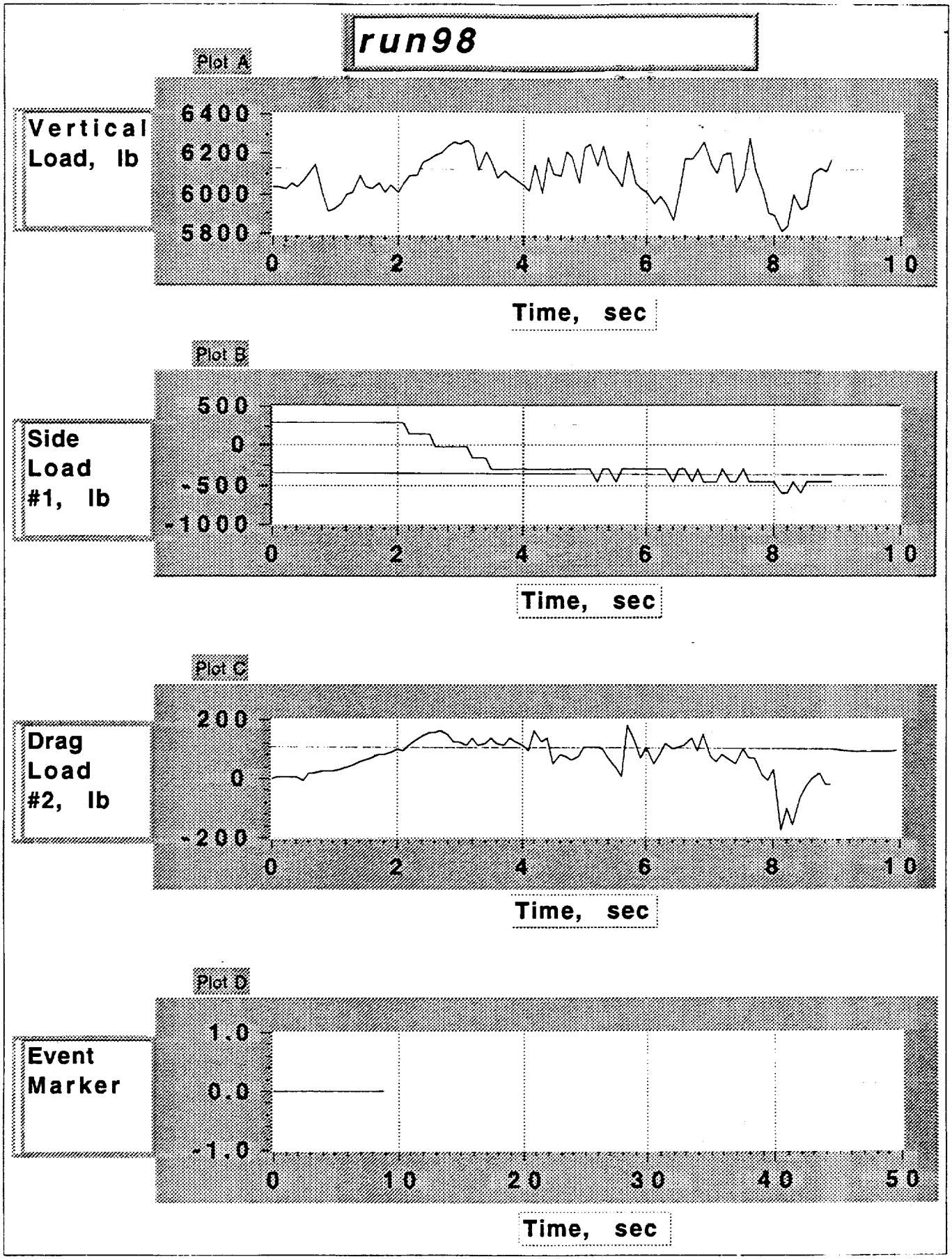

run94n
Plot A
Vertical Load, lb
3600
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
2000
1000
0
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

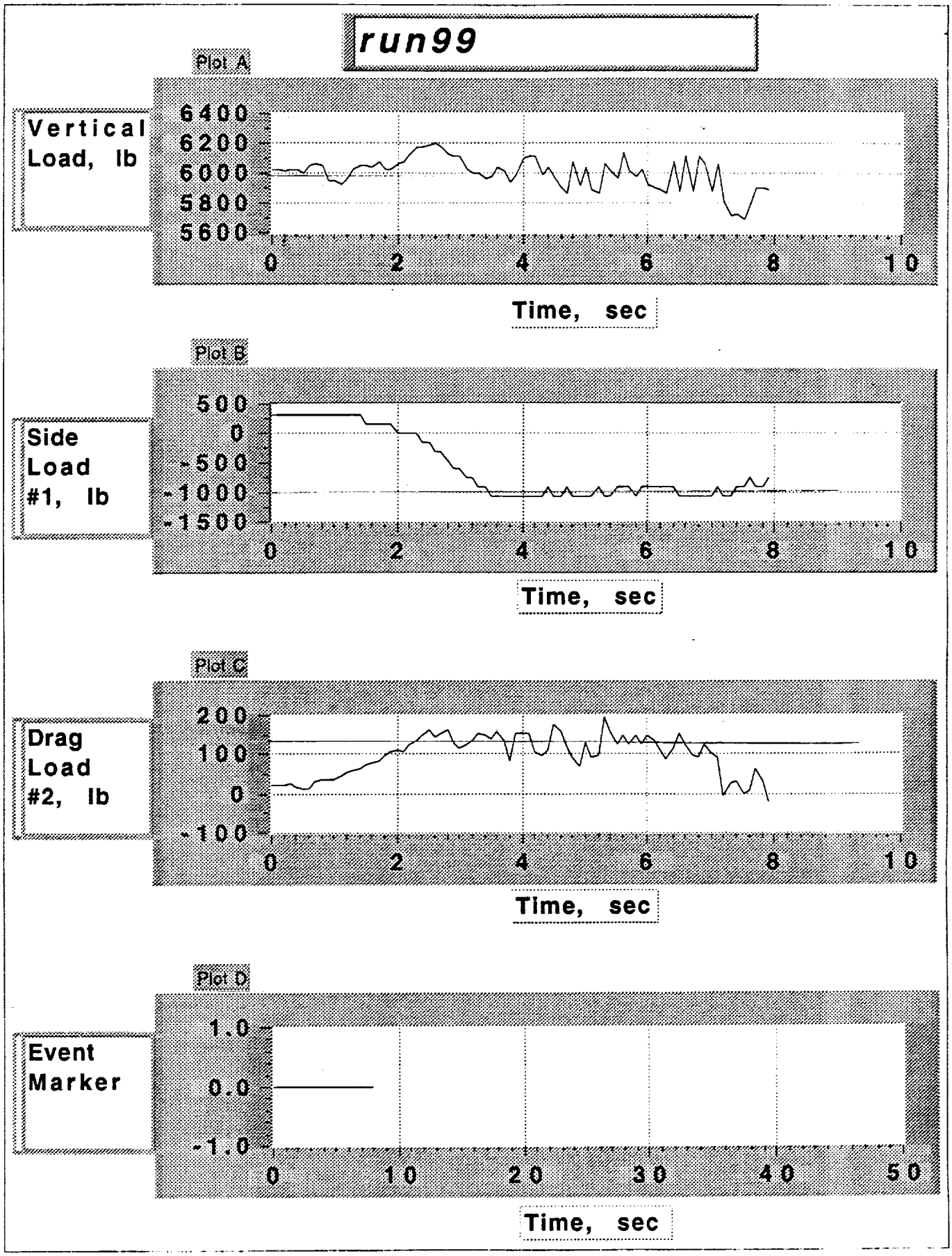

run95
Plot A
Vertical Load, lb
3500
3000
2500
2000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

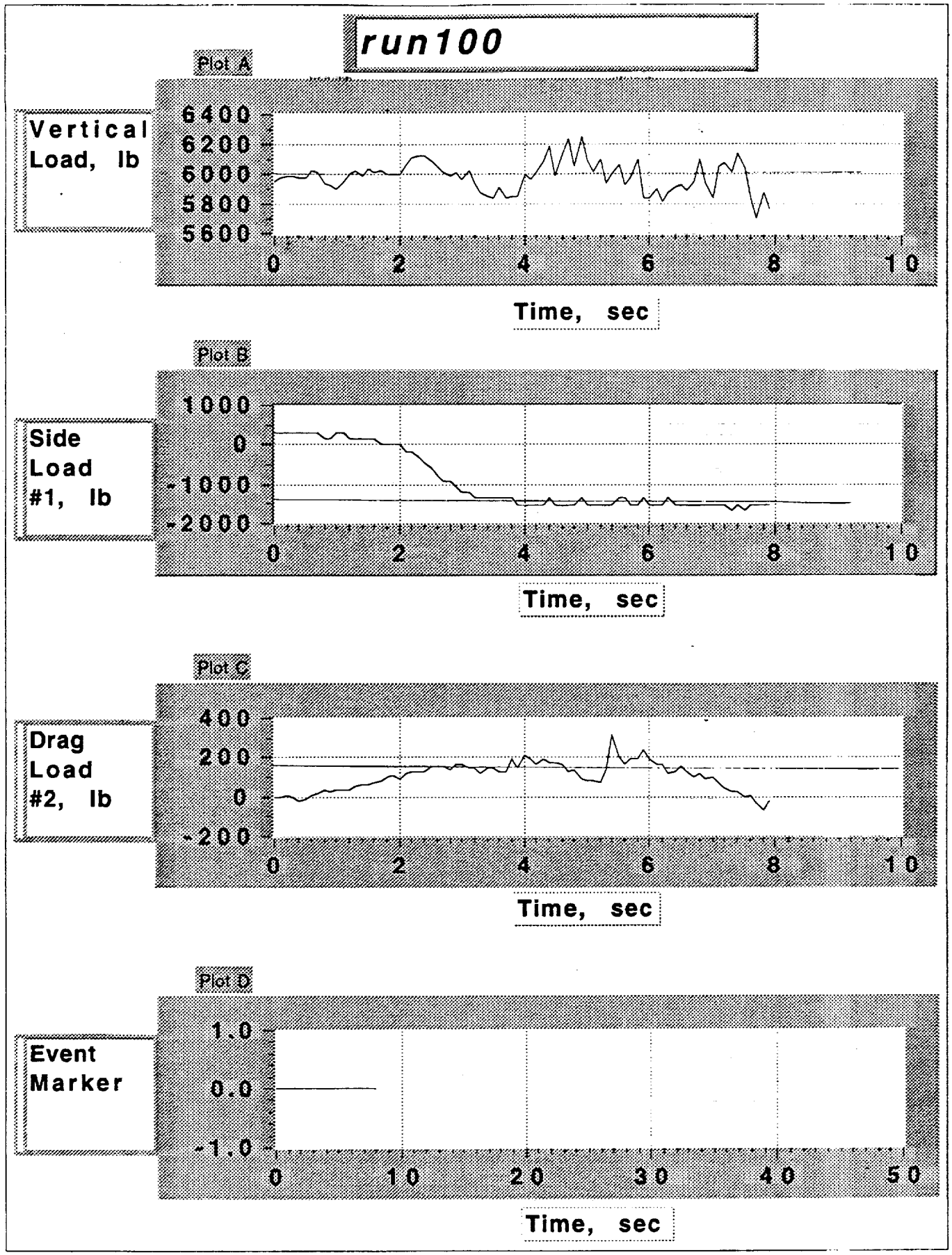

run96
Plot A
Vertical Load, lb
3500
3000
2500
2000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

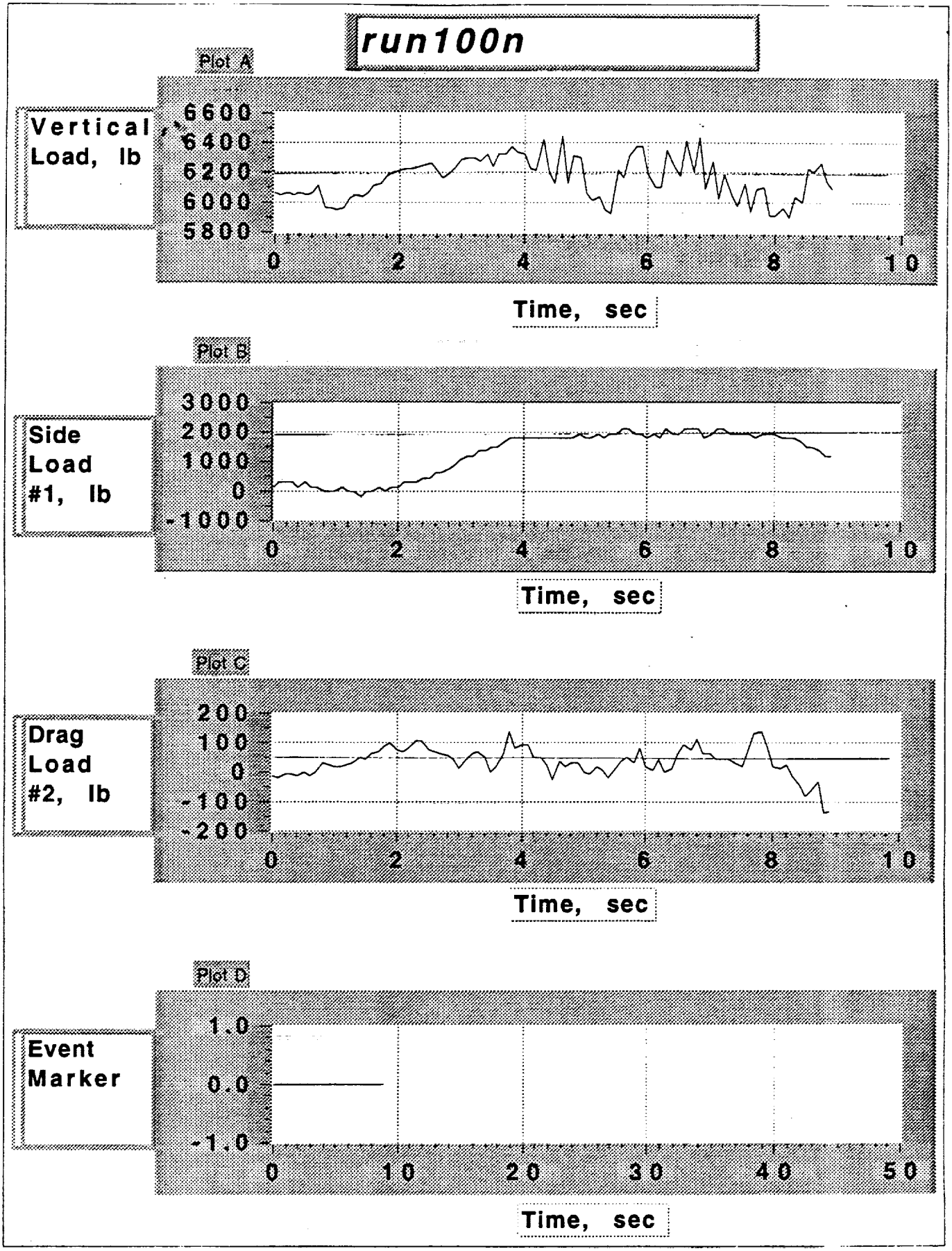

run96n
Plot A
Vertical Load, lb
3500
3000
2500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
3000
2000
1000
0
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
-400
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

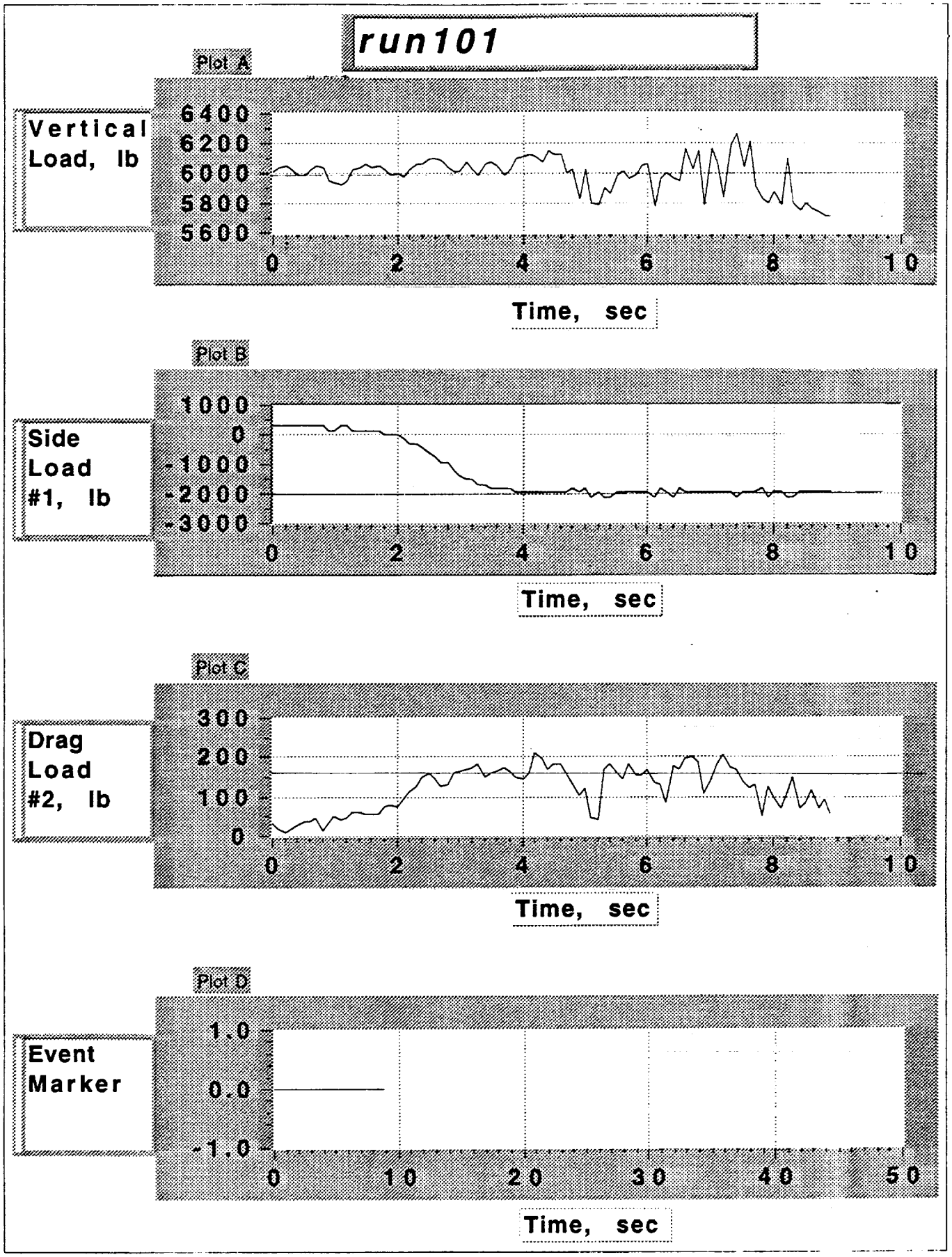

run97
Plot A
Vertical Load, lb
6400
6200
6000
5800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

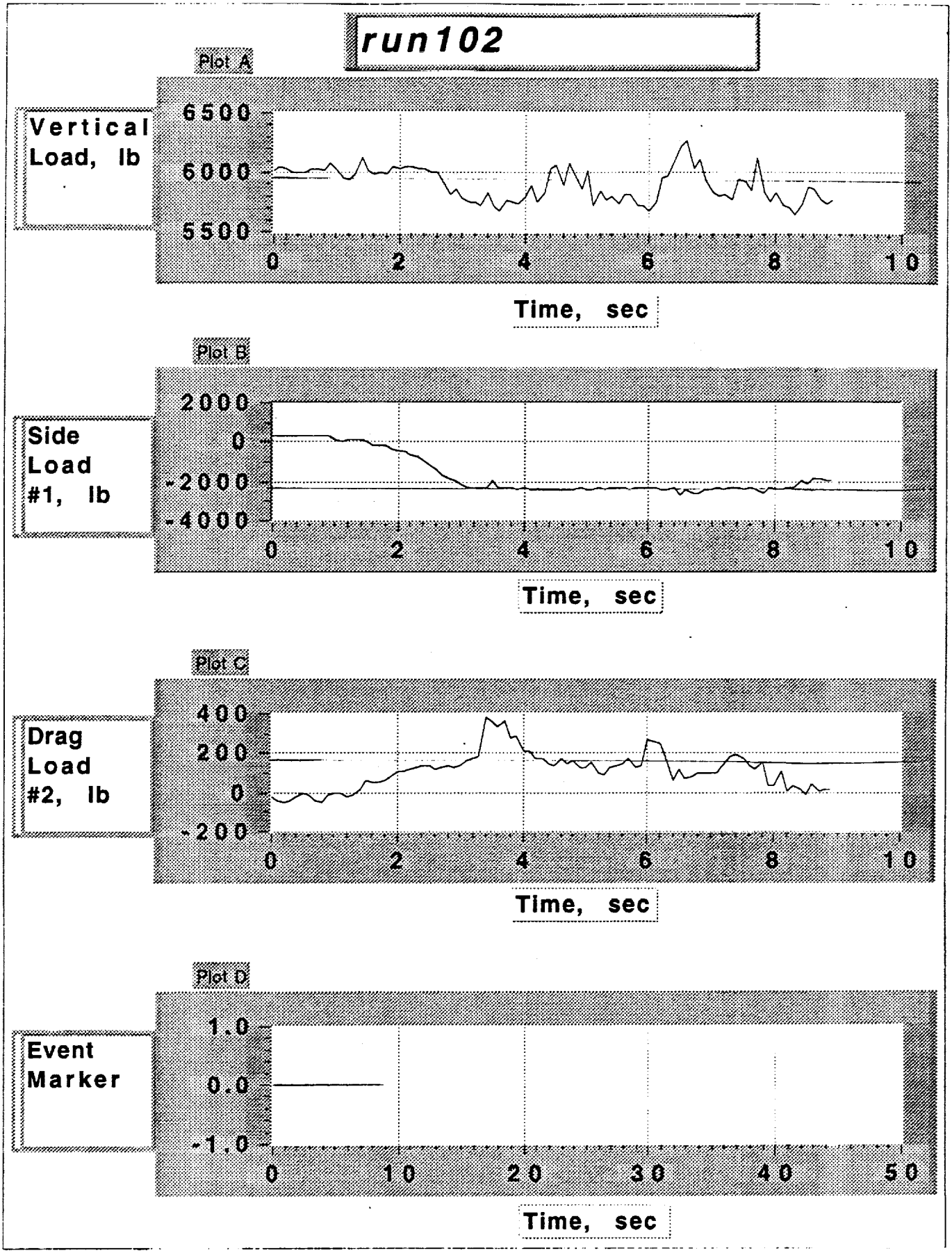

run98
Plot A
Vertical Load, lb
6400
6200
6000
5800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

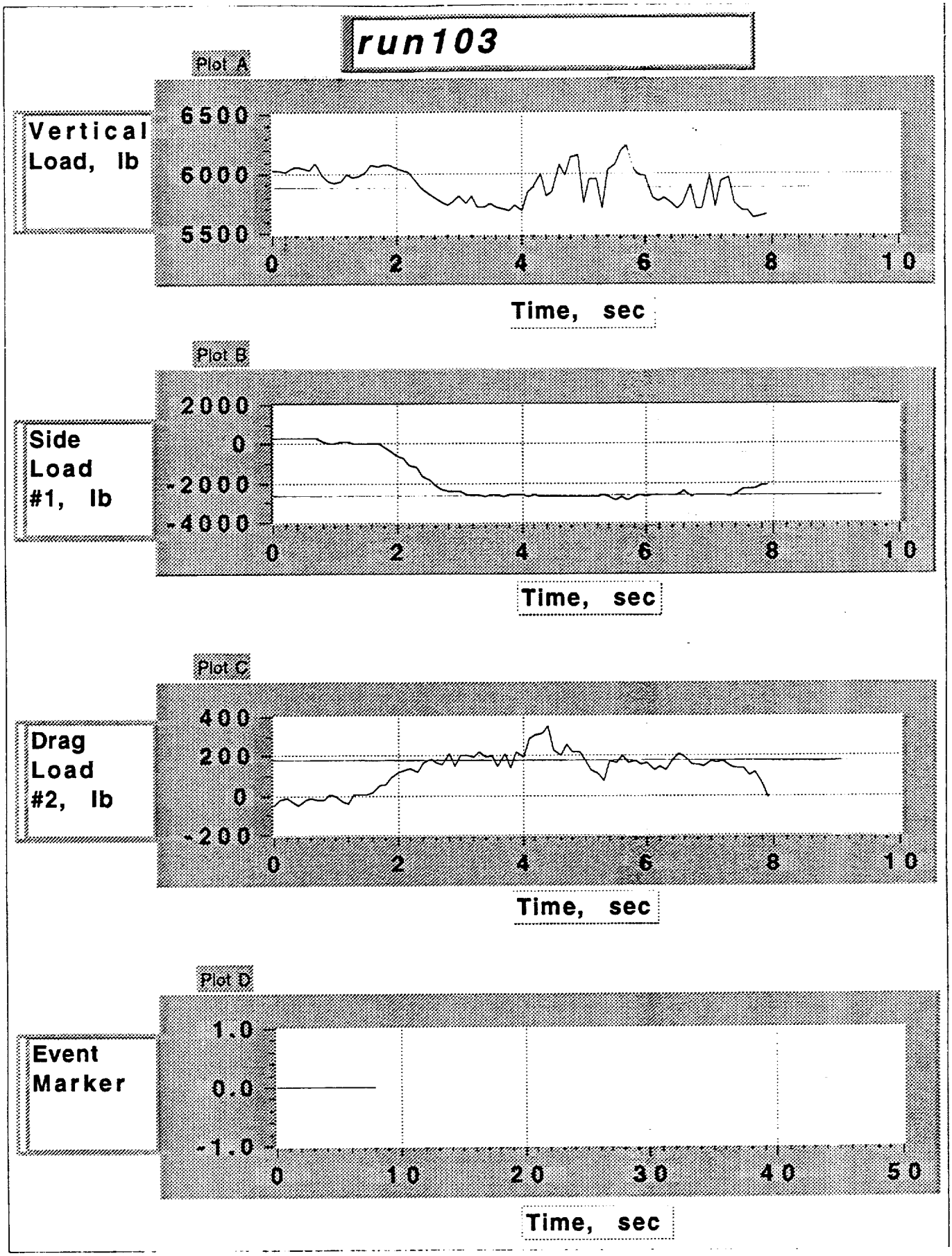

run99
Plot A
Vertical Load, lb
6400
6200
6000
5800
5600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
-1500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

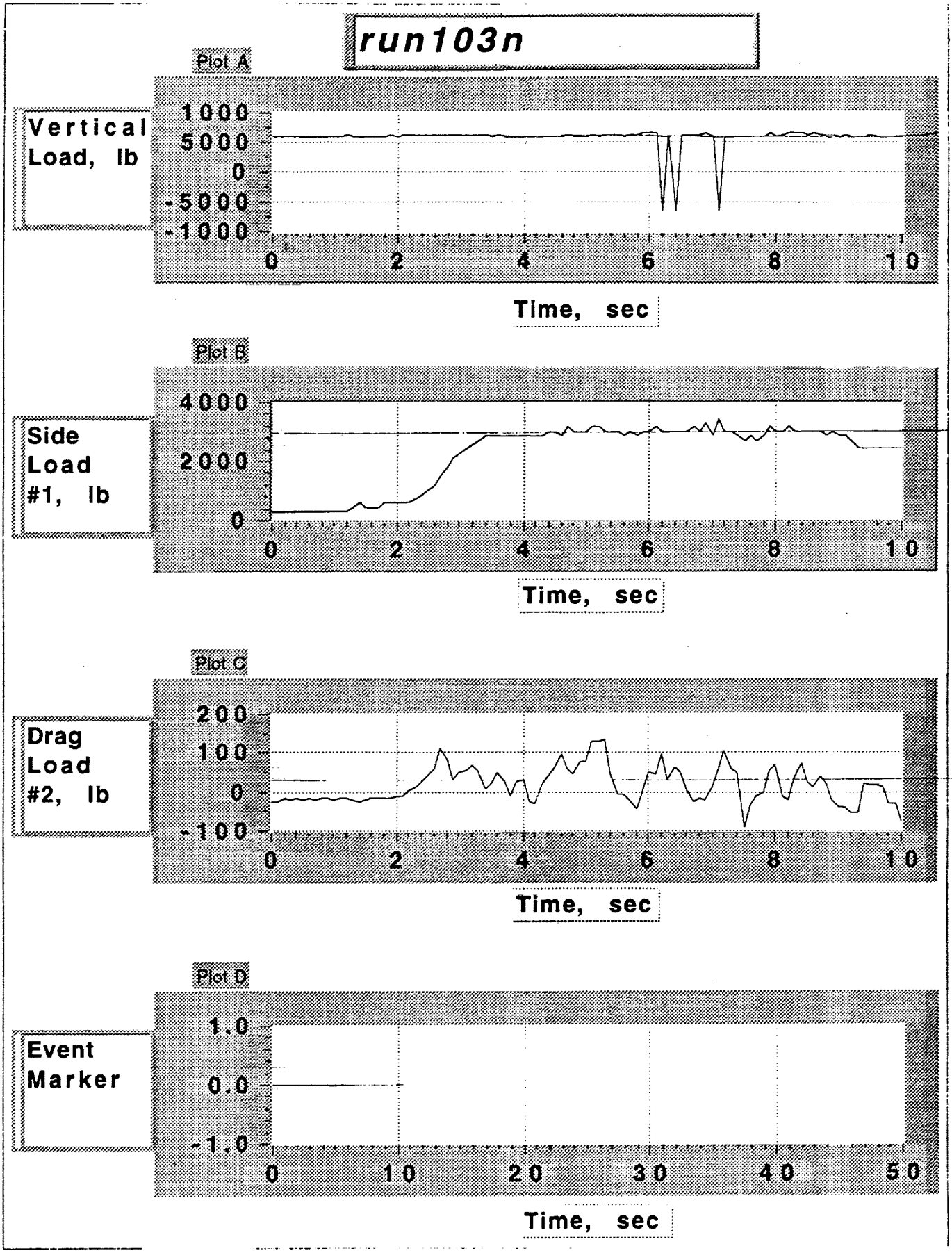

run100
Plot A
Vertical Load, lb
6400
6200
6000
5800
5600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

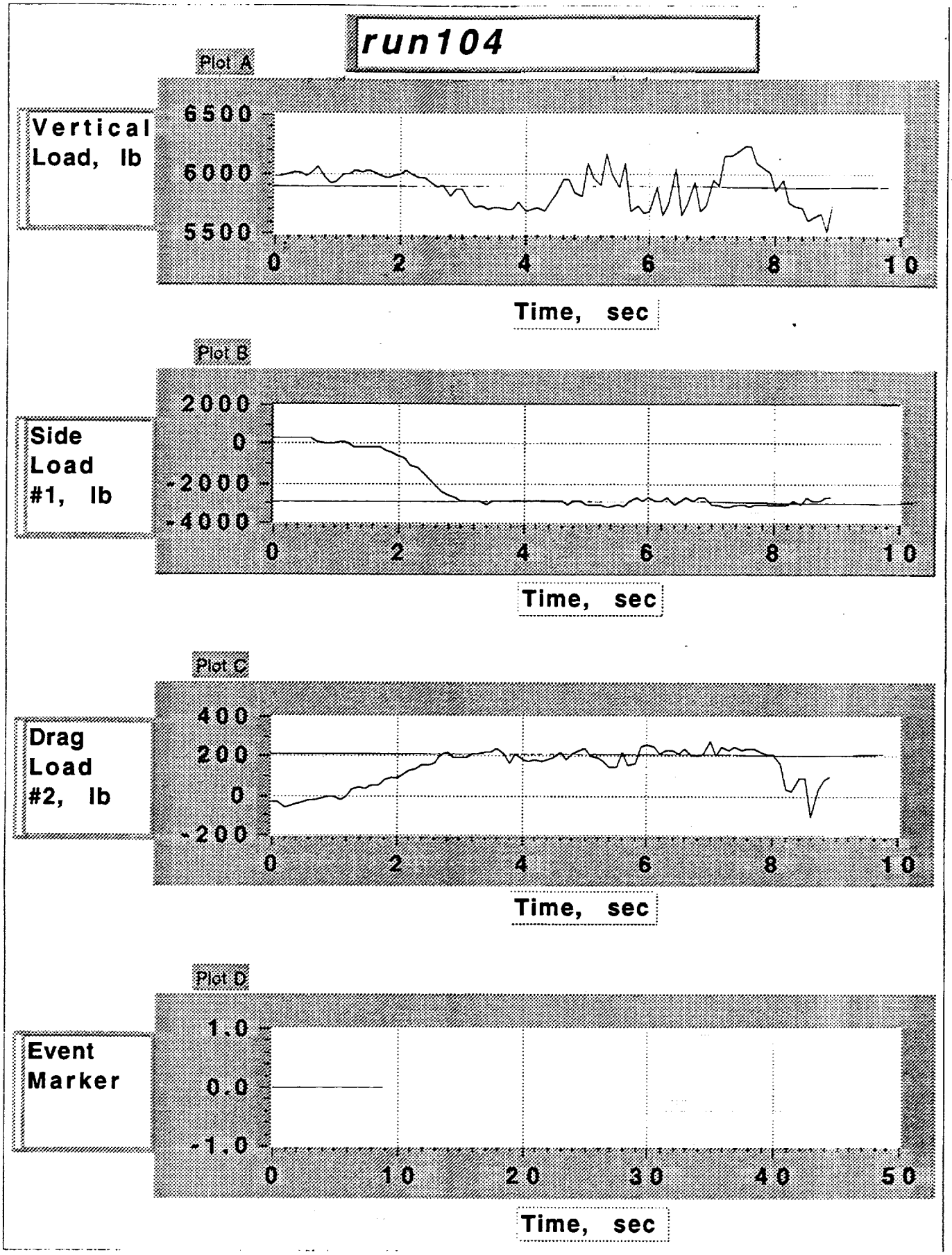

run100n
Plot A
Vertical Load, lb
6600
6400
6200
6000
5800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
3000
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

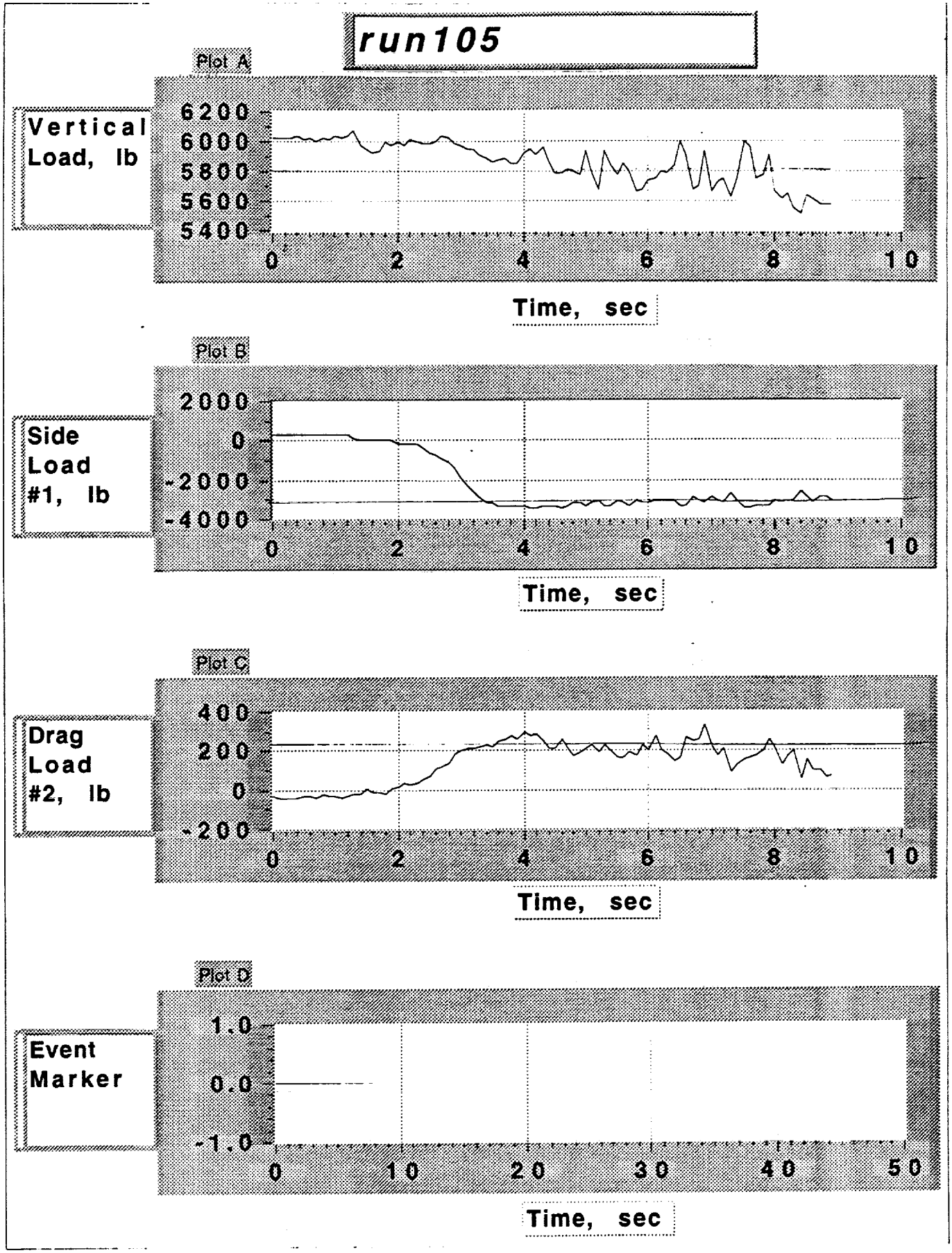

run101
Plot A
Vertical Load, lb
6400
6200
6000
5800
5600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
-3000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
300
200
100
0
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

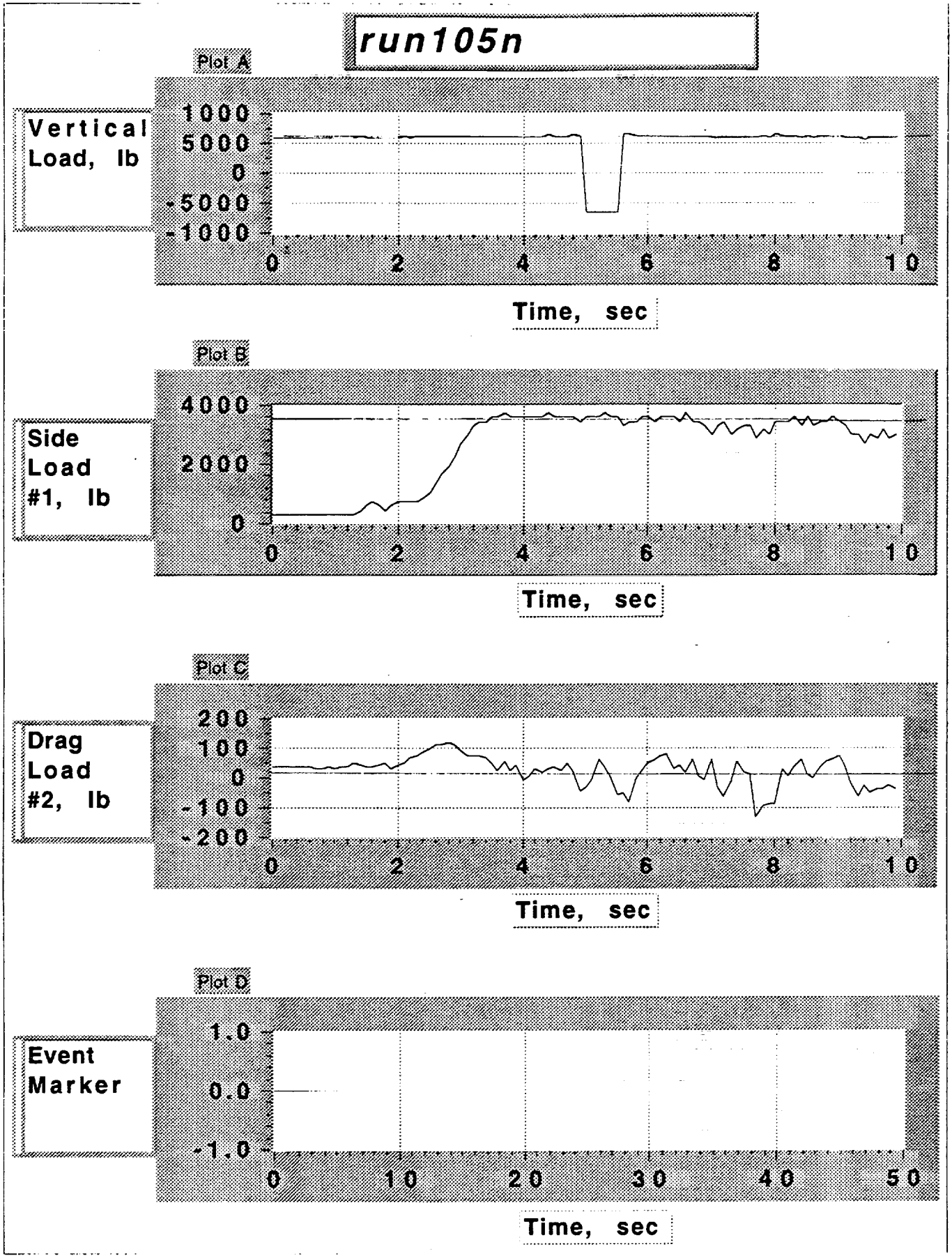

run102
Plot A
Vertical Load, lb
6500
6000
5500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
2000
0
-2000
-4000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

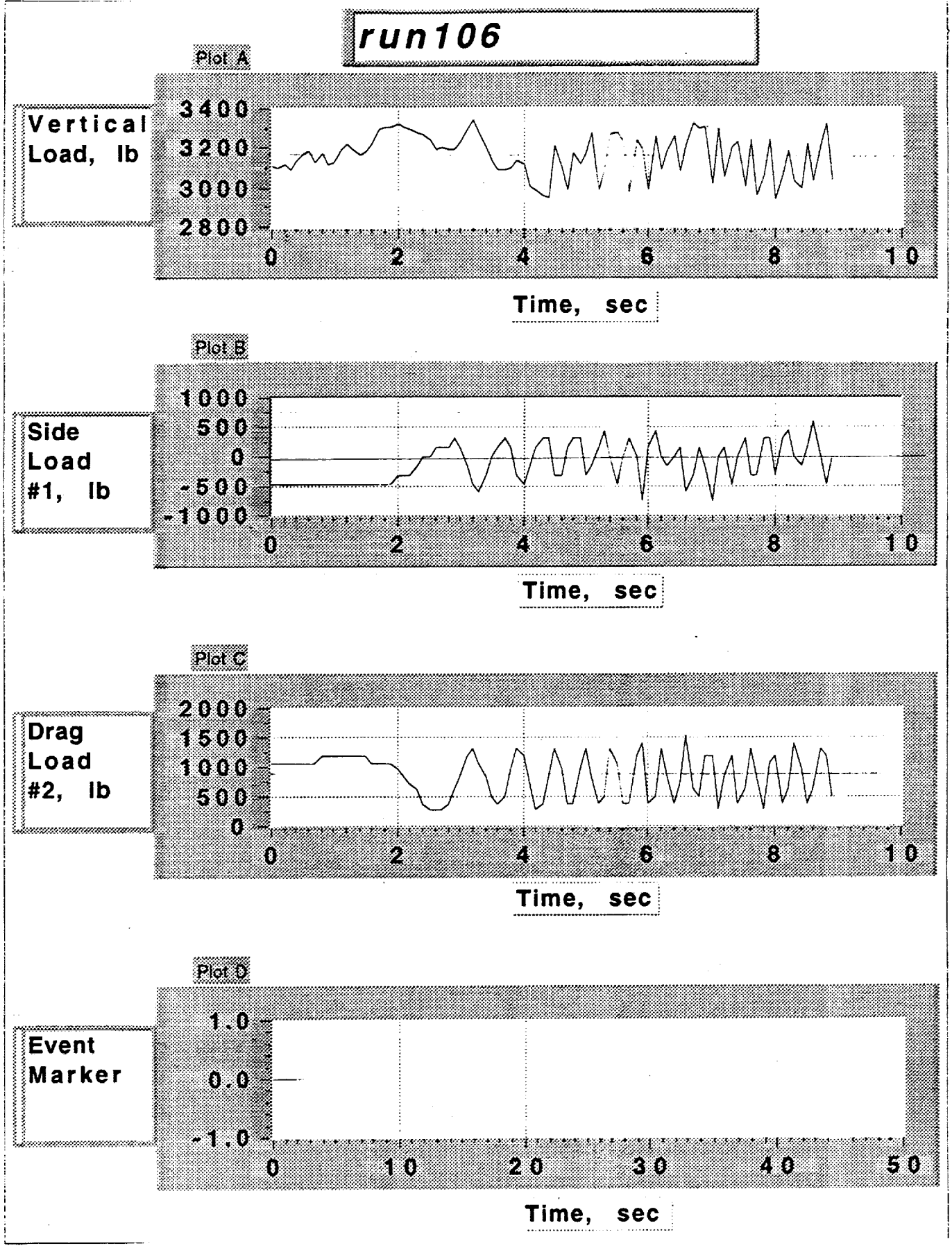

run103
Plot A
Vertical Load, lb
6500
6000
5500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
2000
0
-2000
-4000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

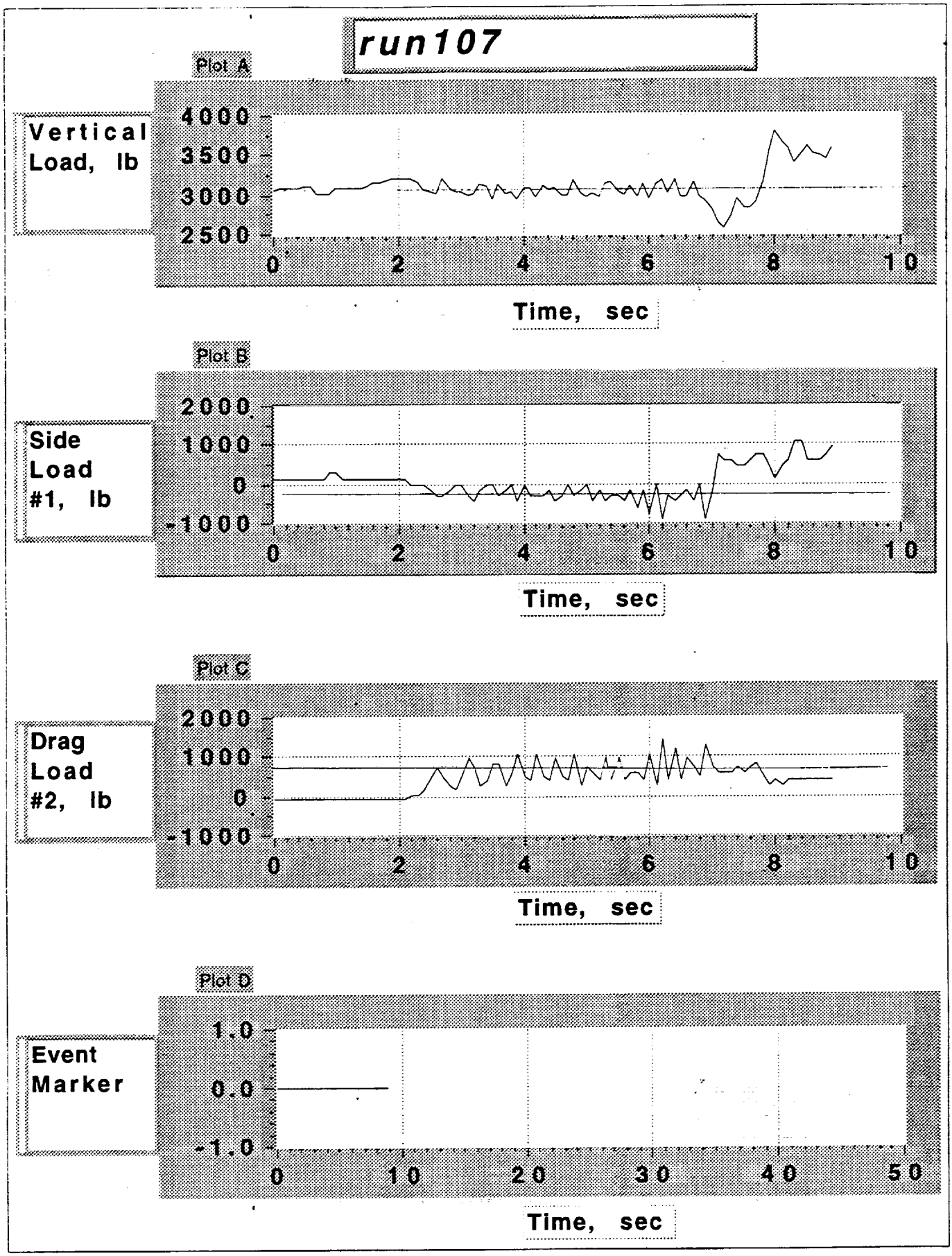

run103n
Plot A
Vertical Load, lb
1000
5000
0
-5000
-1000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
4000
2000
0
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

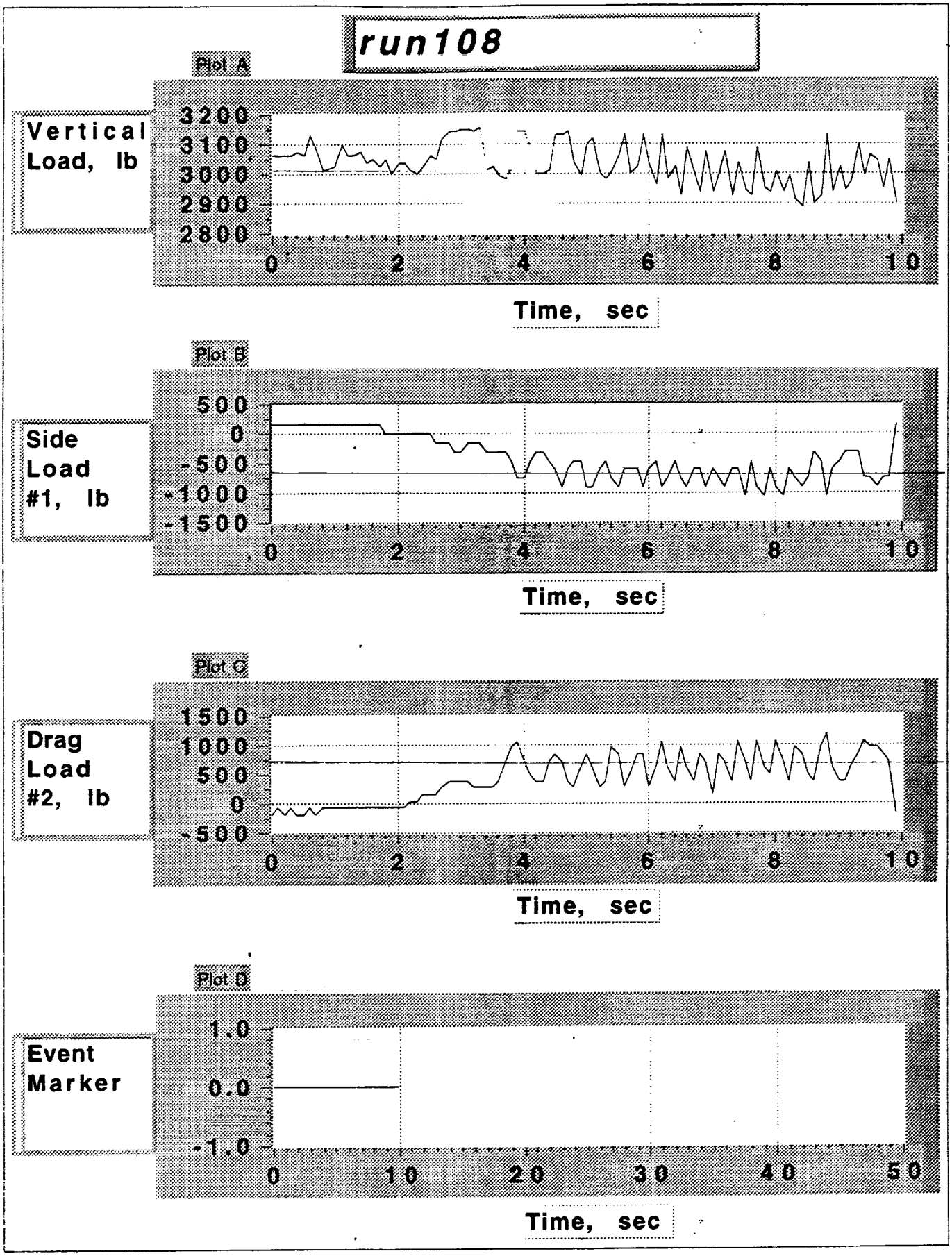

run104
Plot A
Vertical Load, lb
6500
6000
5500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
2000
0
-2000
-4000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

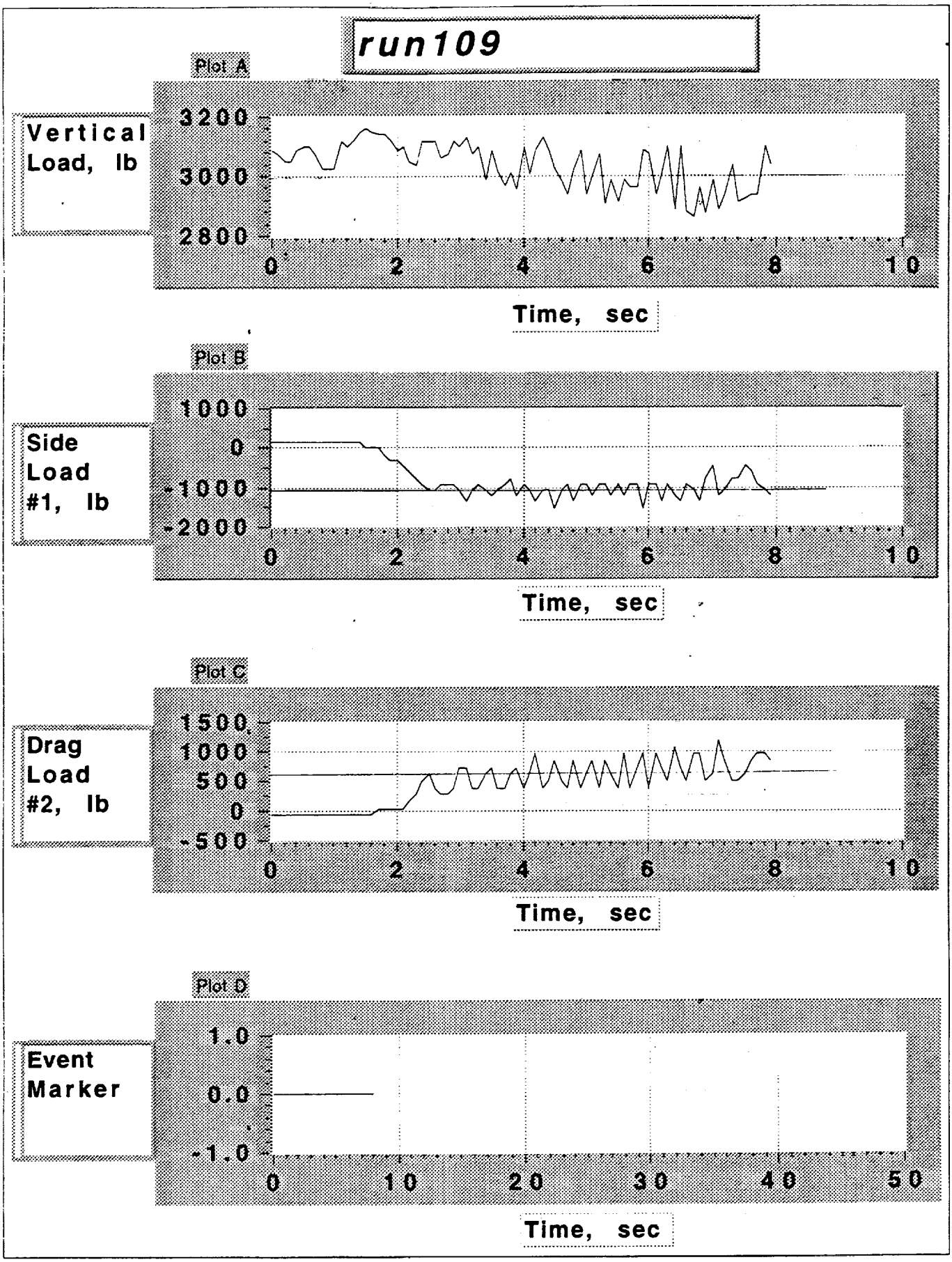

run105
Plot A
Vertical Load, lb
6200
6000
5800
5600
5400
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
2000
0
-2000
-4000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
400
200
0
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

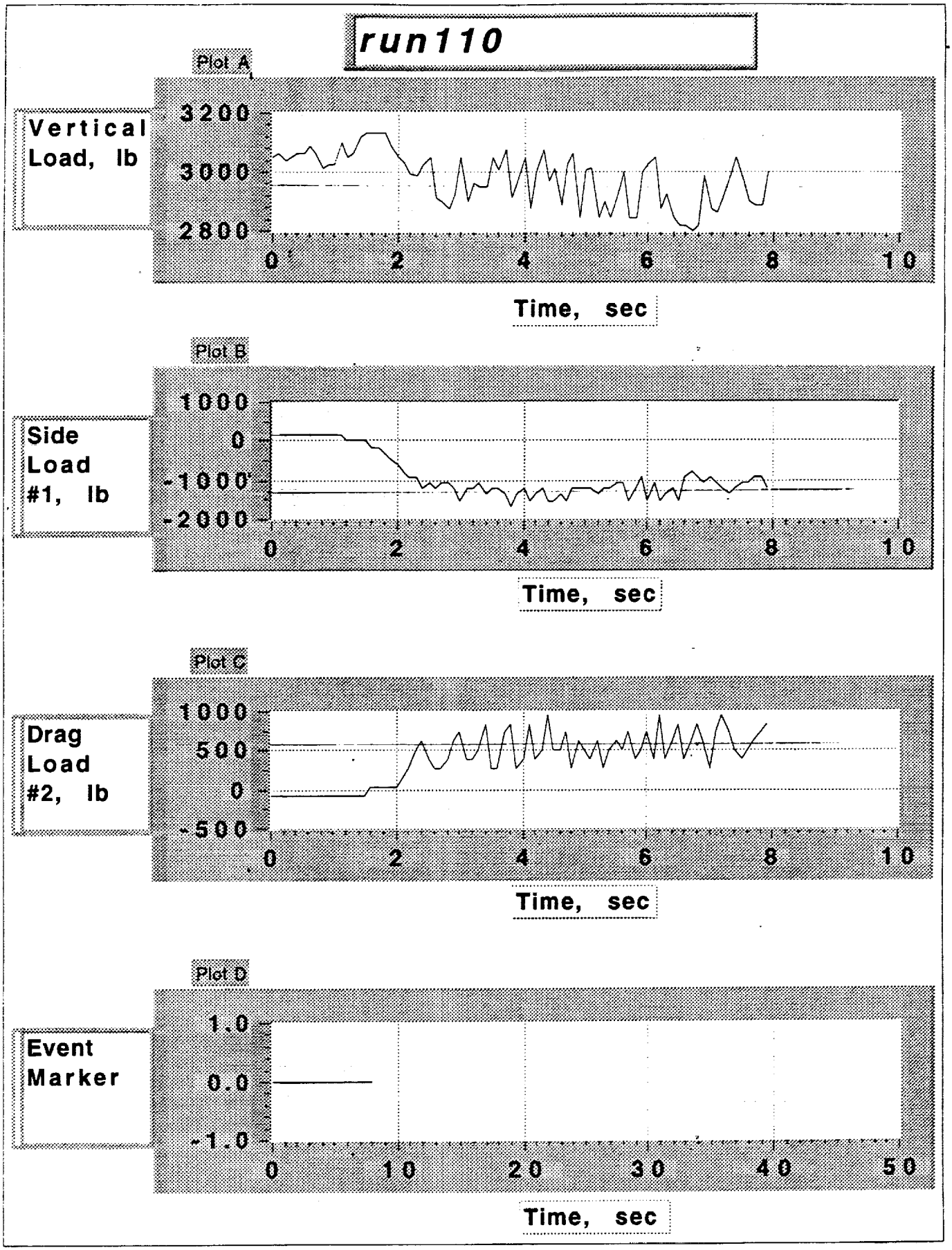

run105n
Plot A
Vertical Load, lb
1000
5000
0
-5000
-1000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
4000
2000
0
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

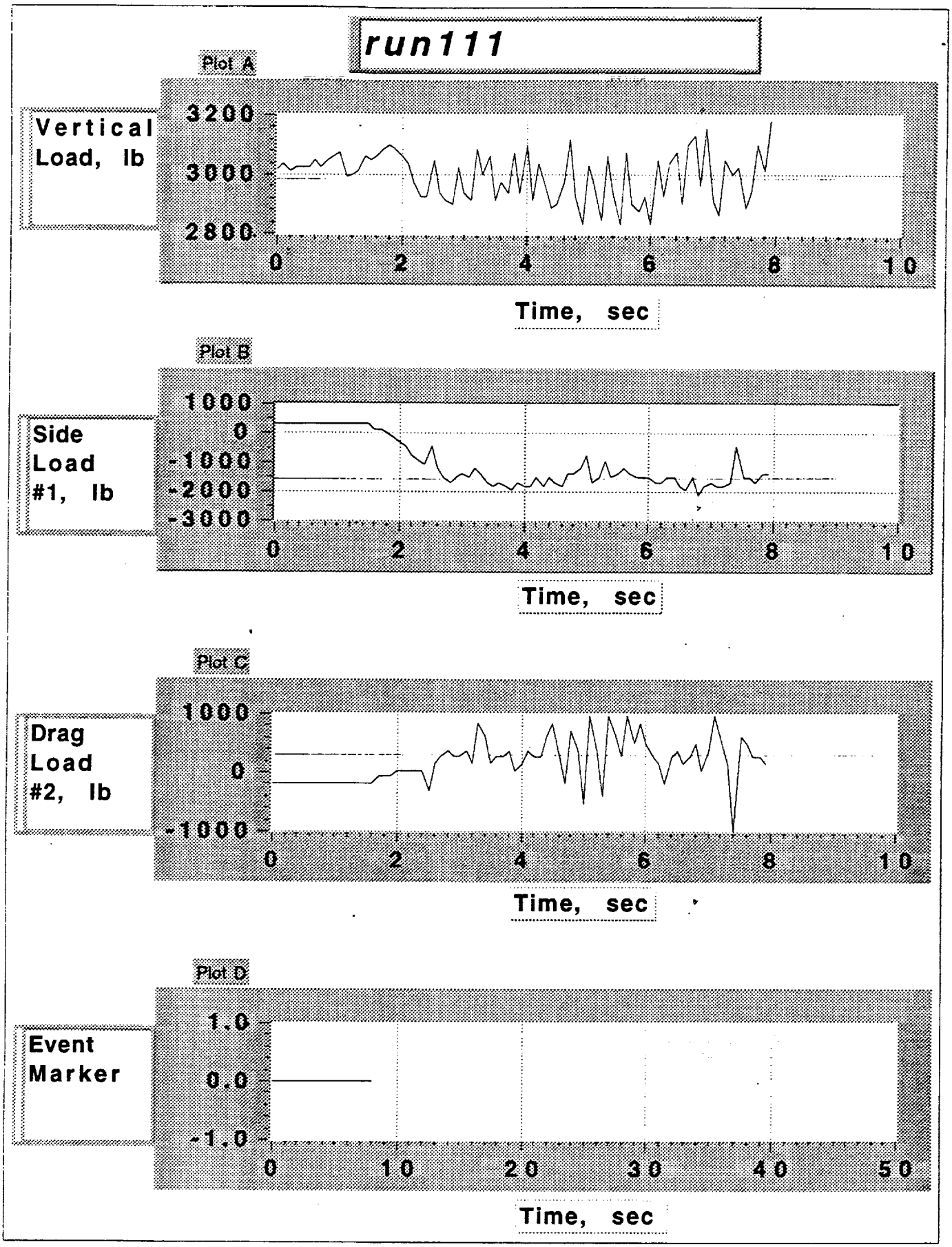

run106
Plot A
Vertical Load, lb
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
2000
1500
1000
500
0
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

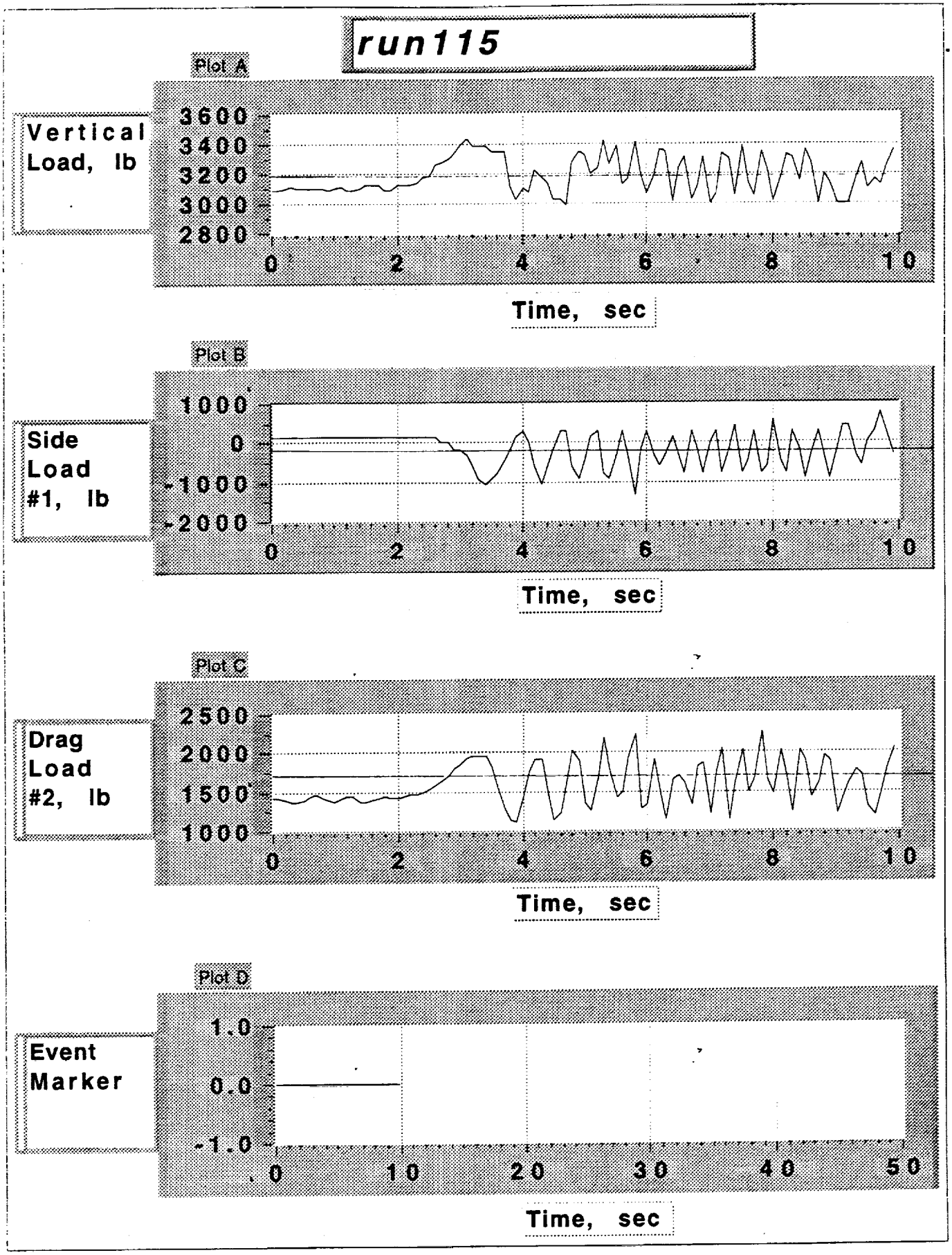

run107
Plot A
Vertical Load, lb
4000
3500
3000
2500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

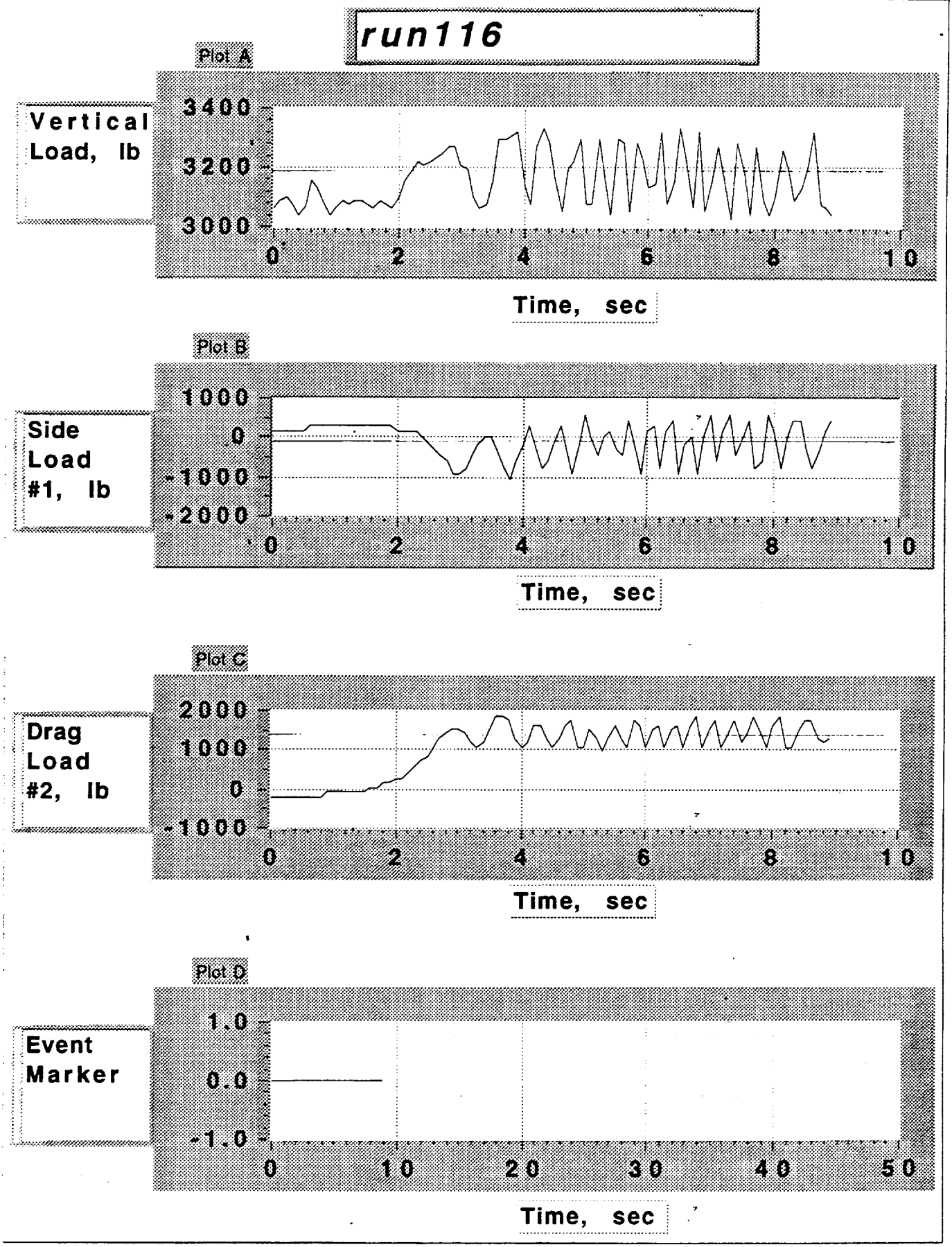

run108
Plot A
Vertical Load, lb
3200
3100
3000
2900
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
-1500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
1500
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

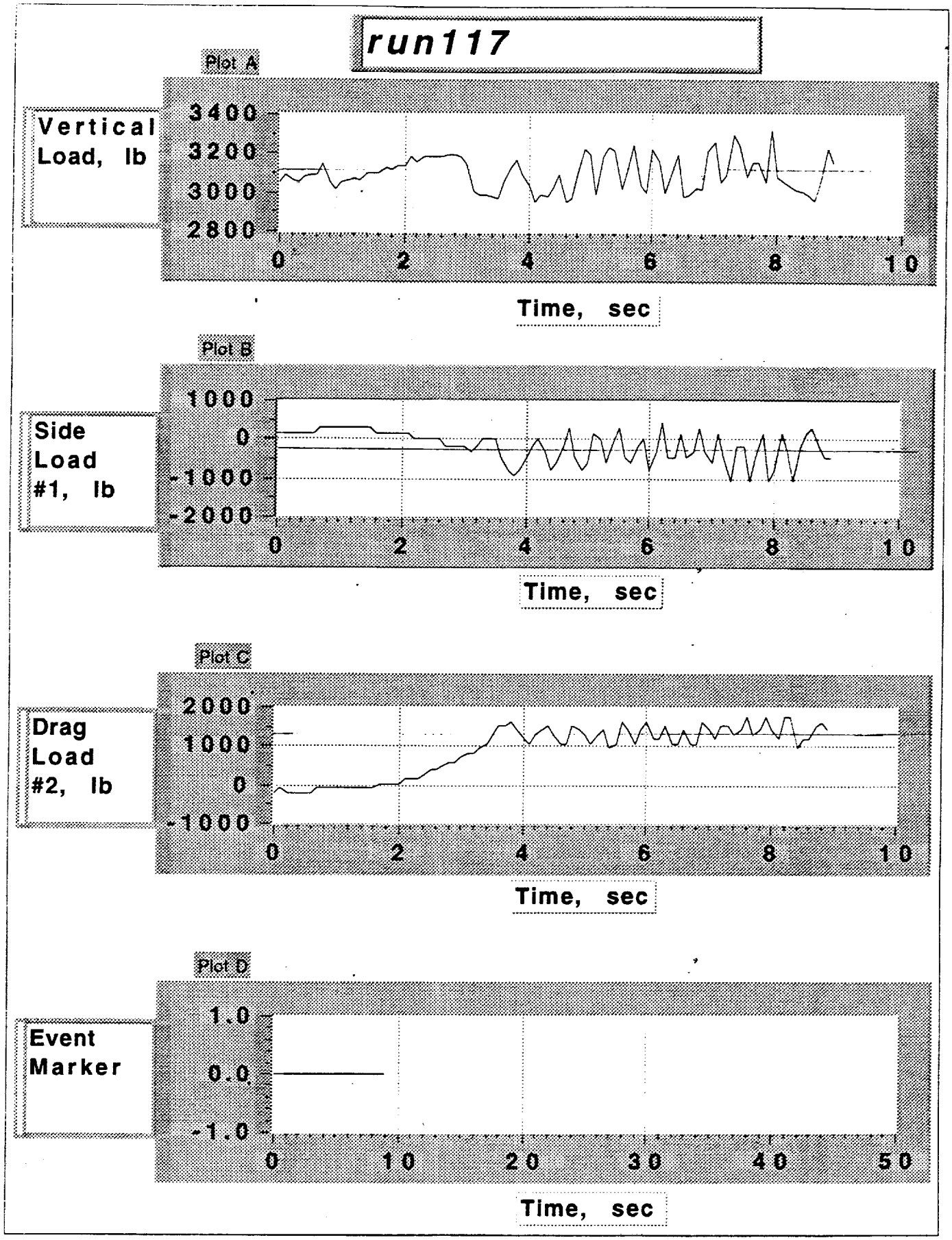

run109
Plot A
Vertical Load, lb
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
1500
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

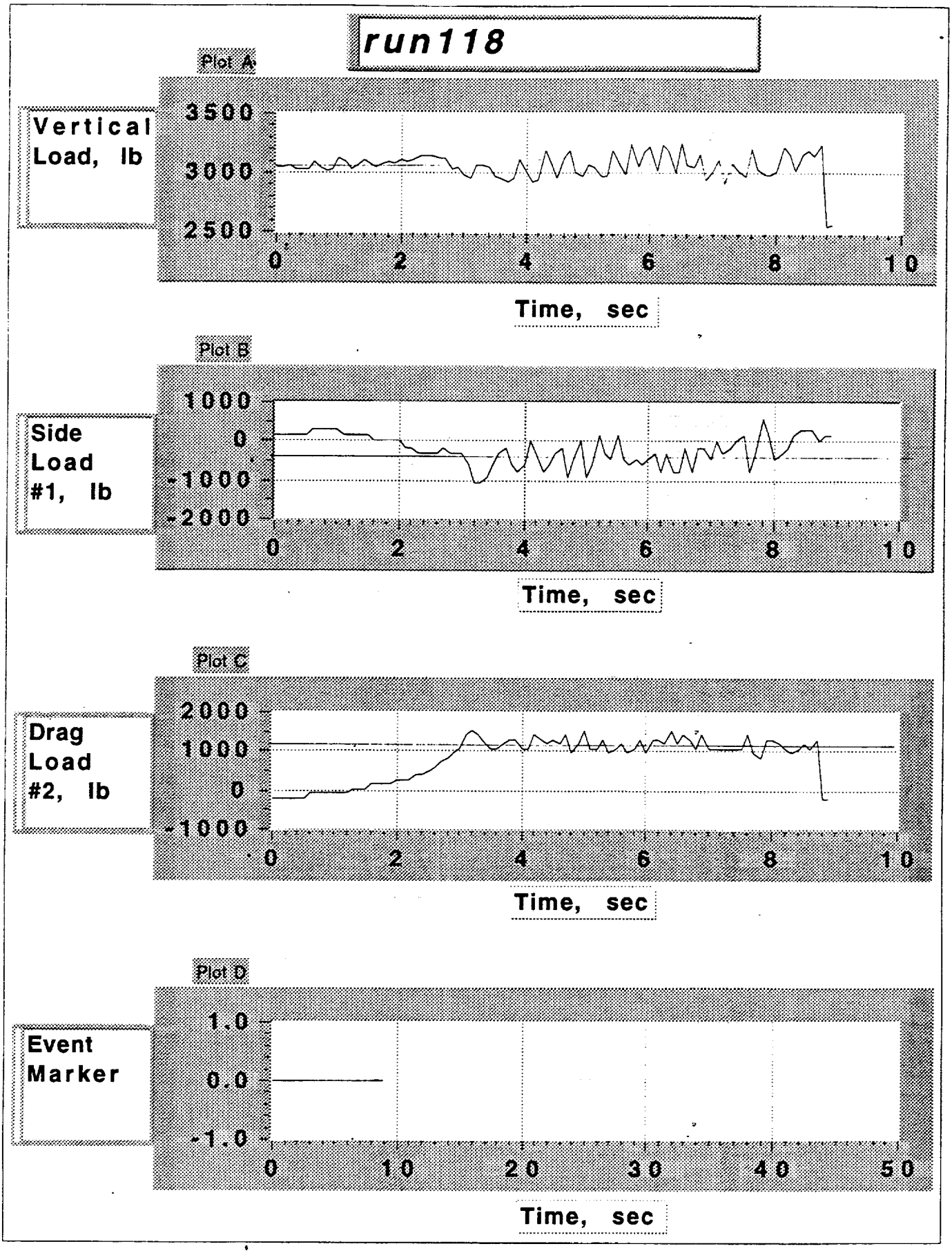

run110
Plot A
Vertical Load, lb
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

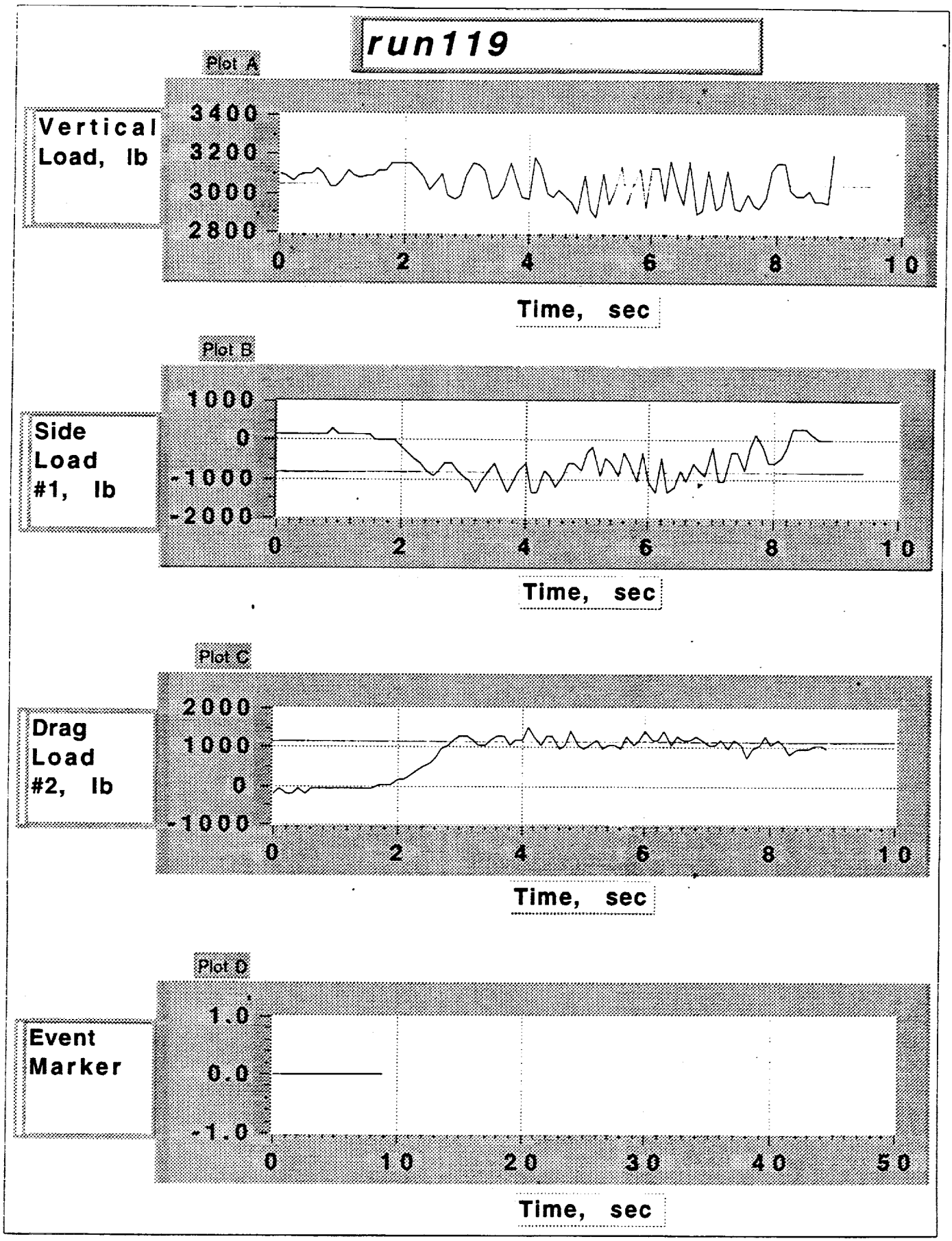

run111
Plot A
Vertical Load, lb
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
-3000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

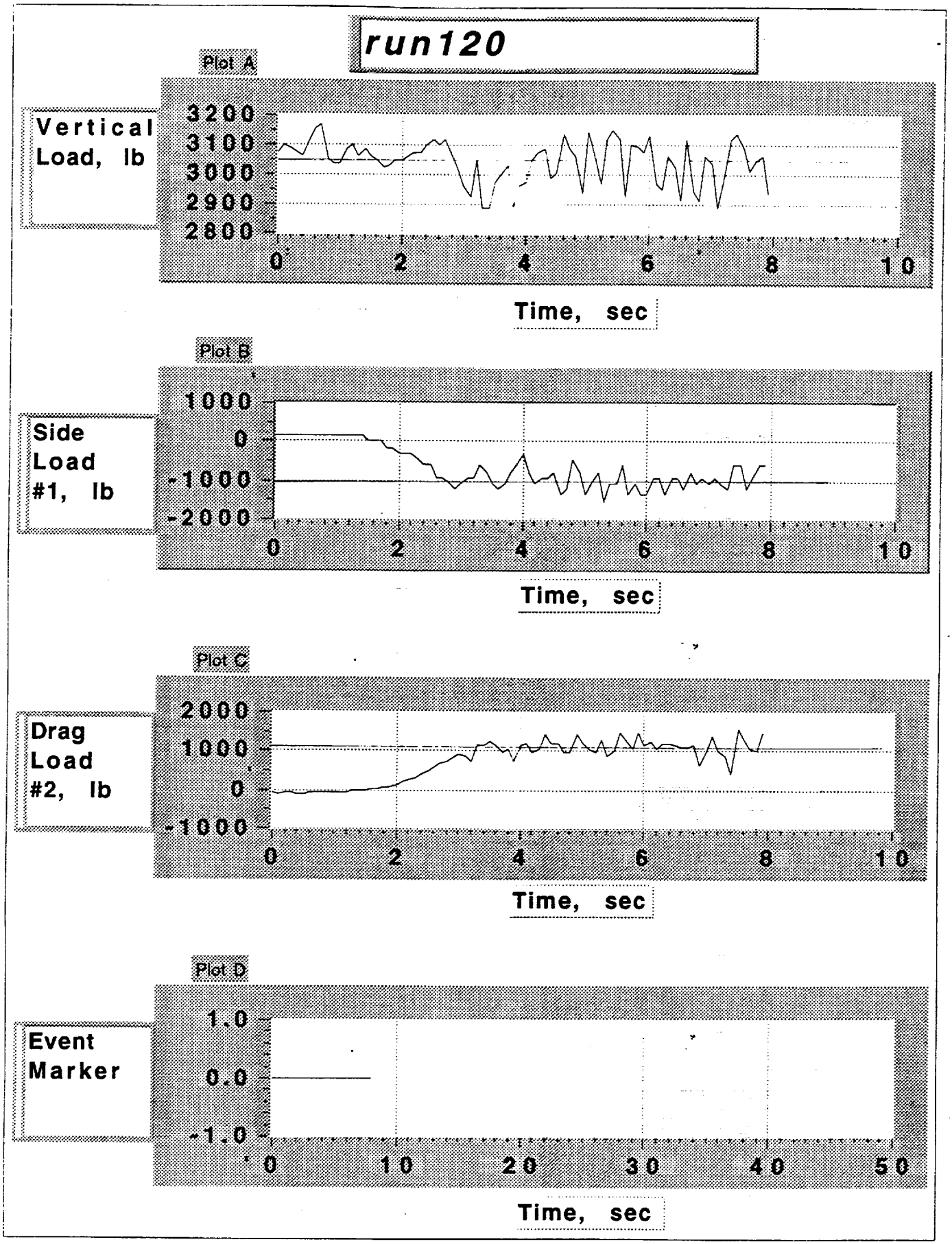

run115
Plot A
Vertical Load, lb
3600
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
2500
2000
1500
1000
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

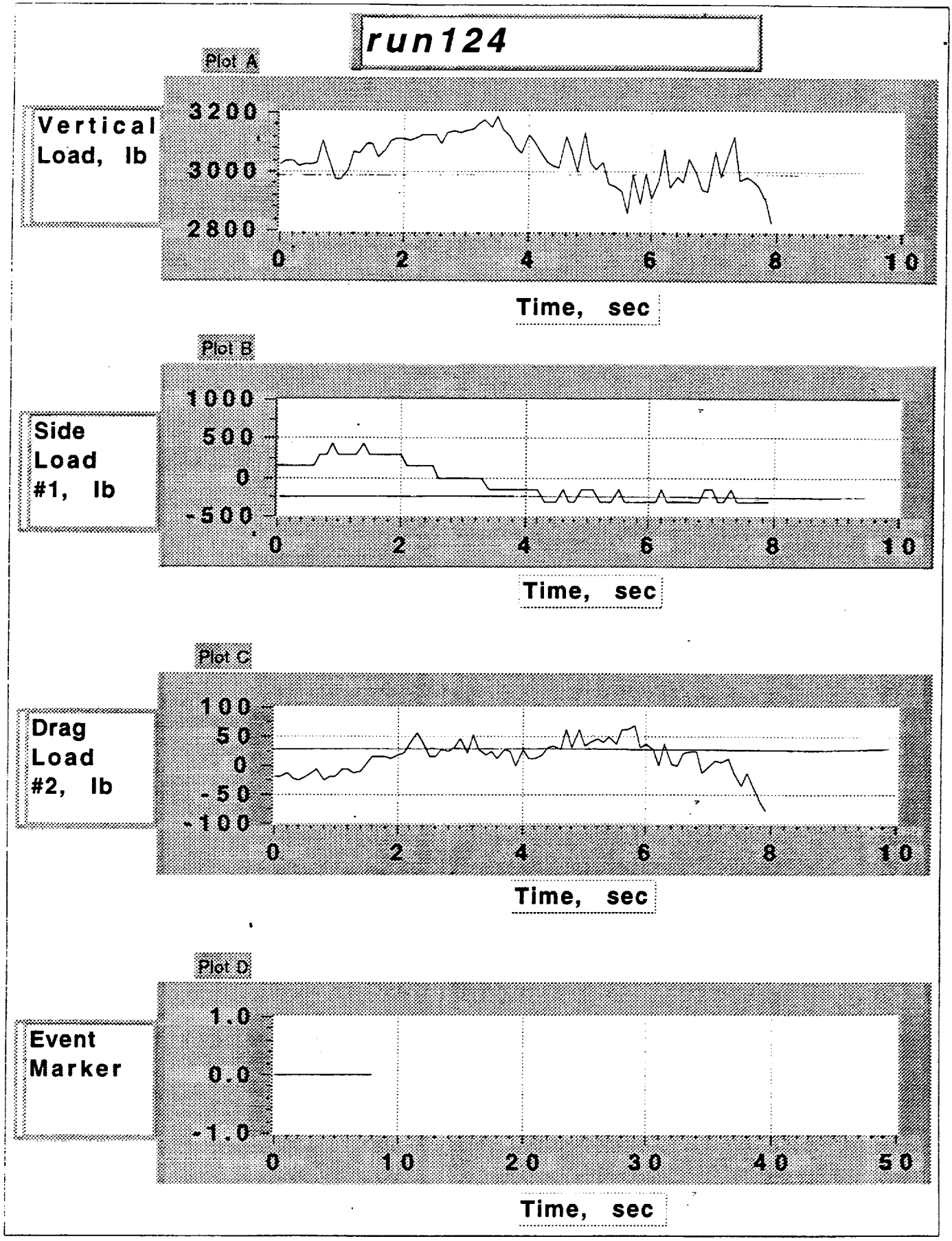

run116
Plot A
Vertical Load, lb
3400
3200
3000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

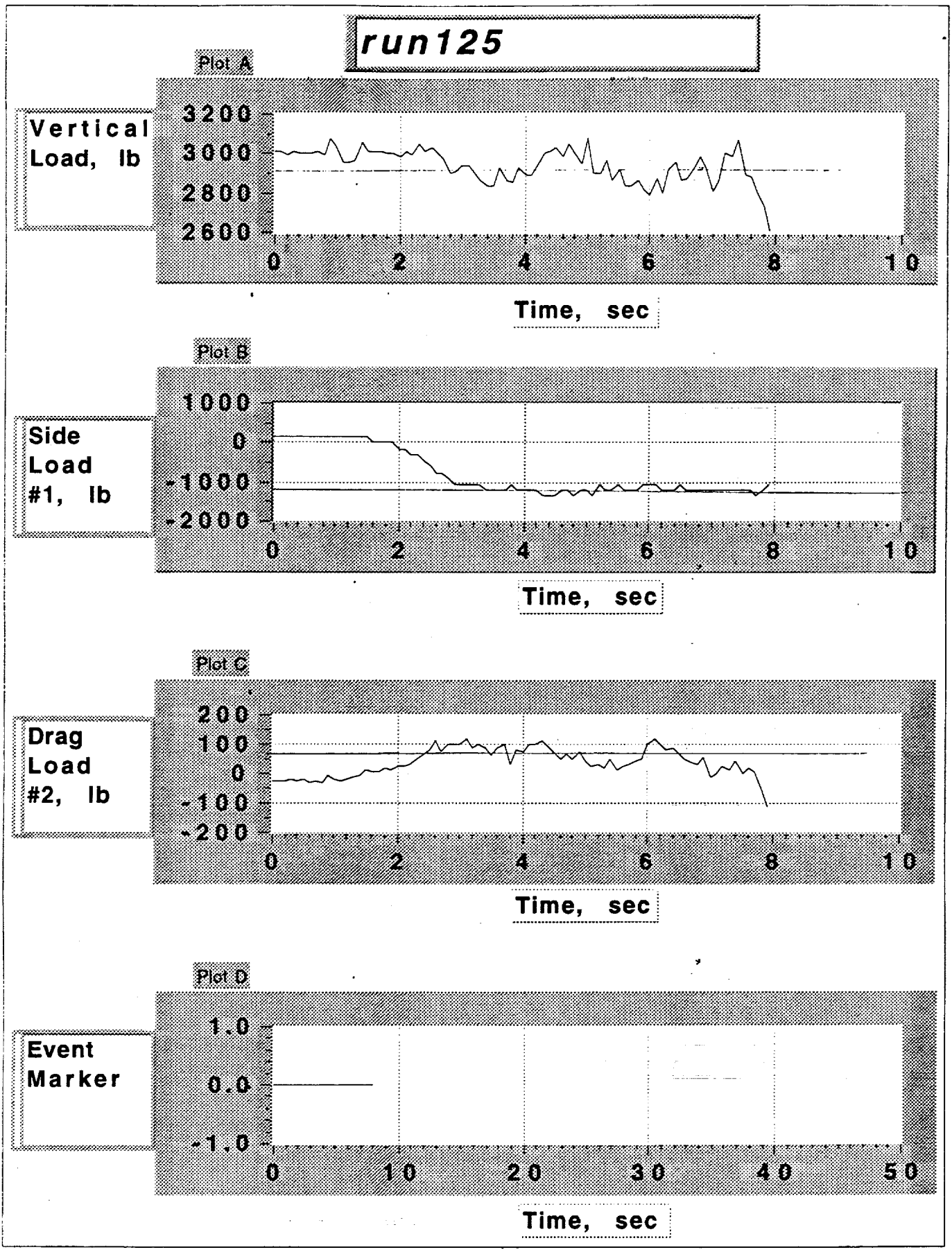

run117
Plot A
Vertical Load, lb
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

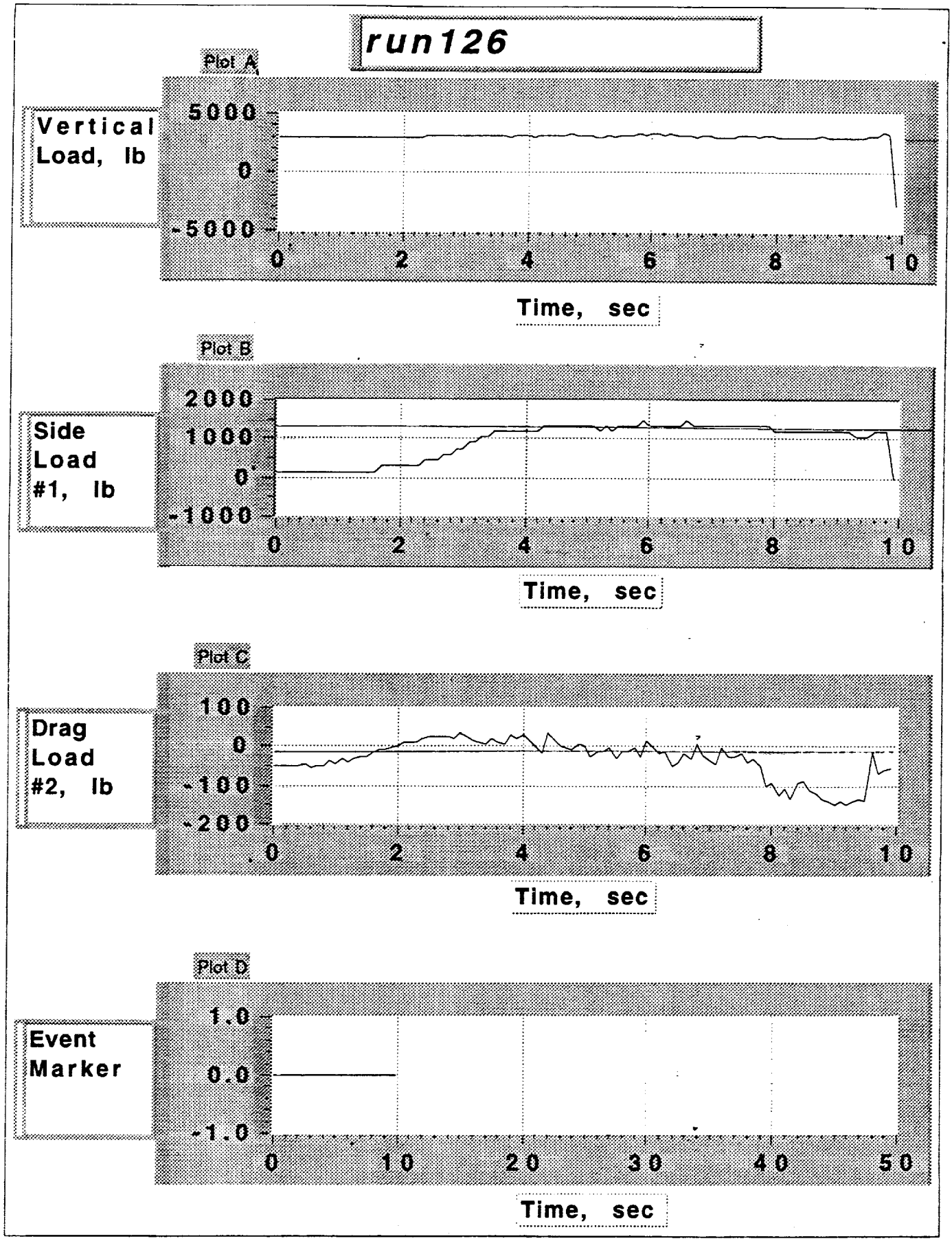

run118
Plot A
Vertical Load, lb
3500
3000
2500
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

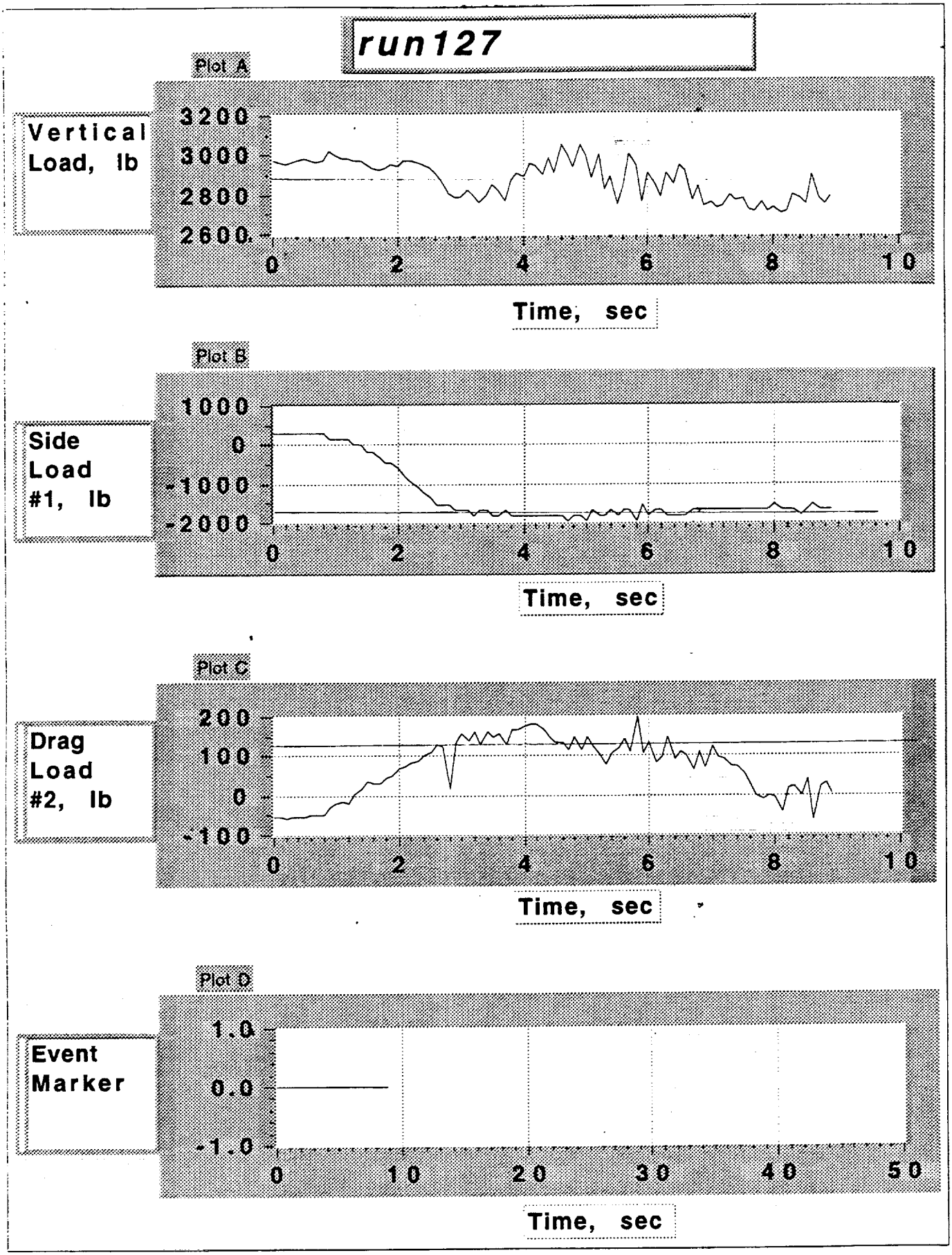

run119
Plot A
Vertical Load, lb
3400
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

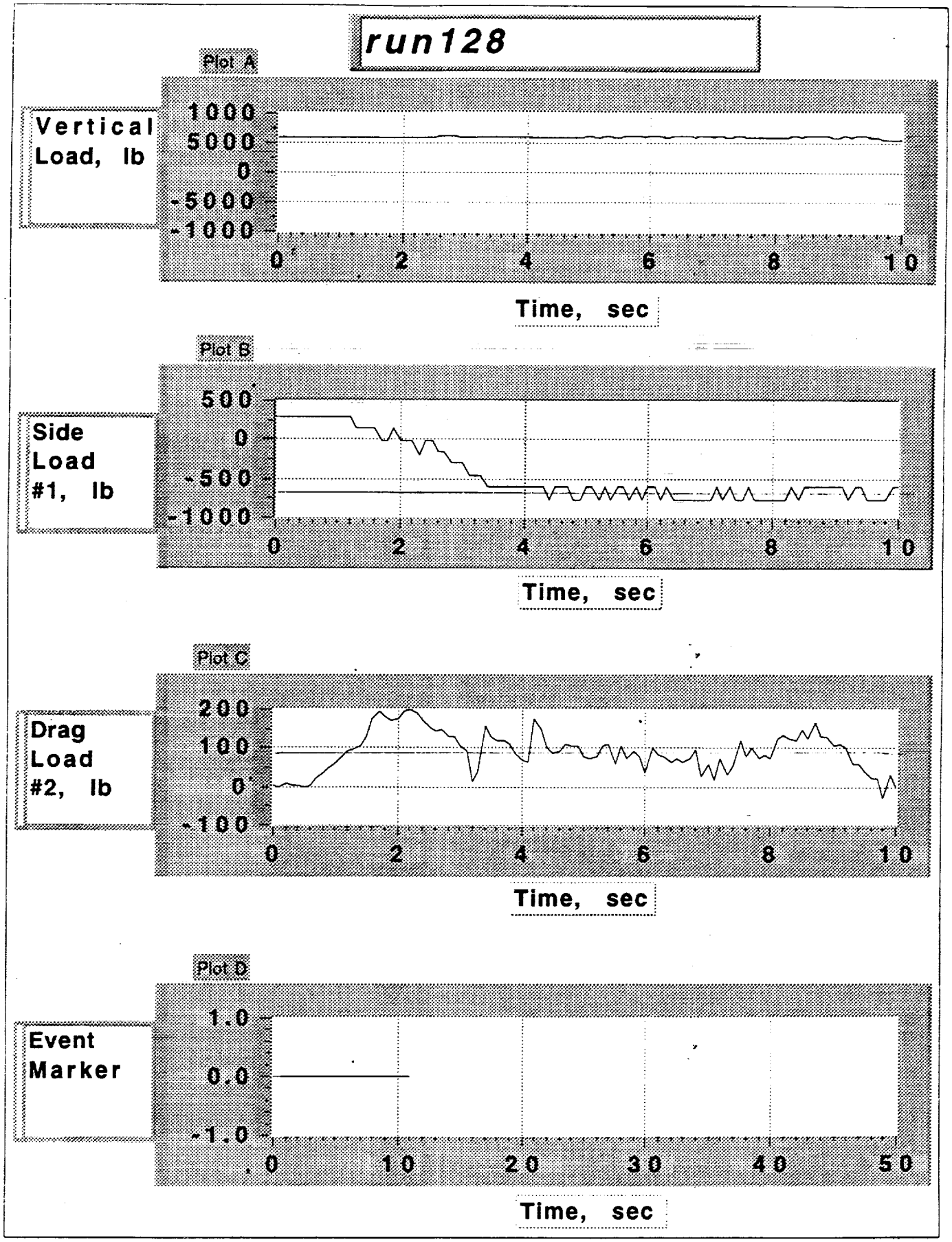

run120
Plot A
Vertical Load, lb
3200
3100
3000
2900
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

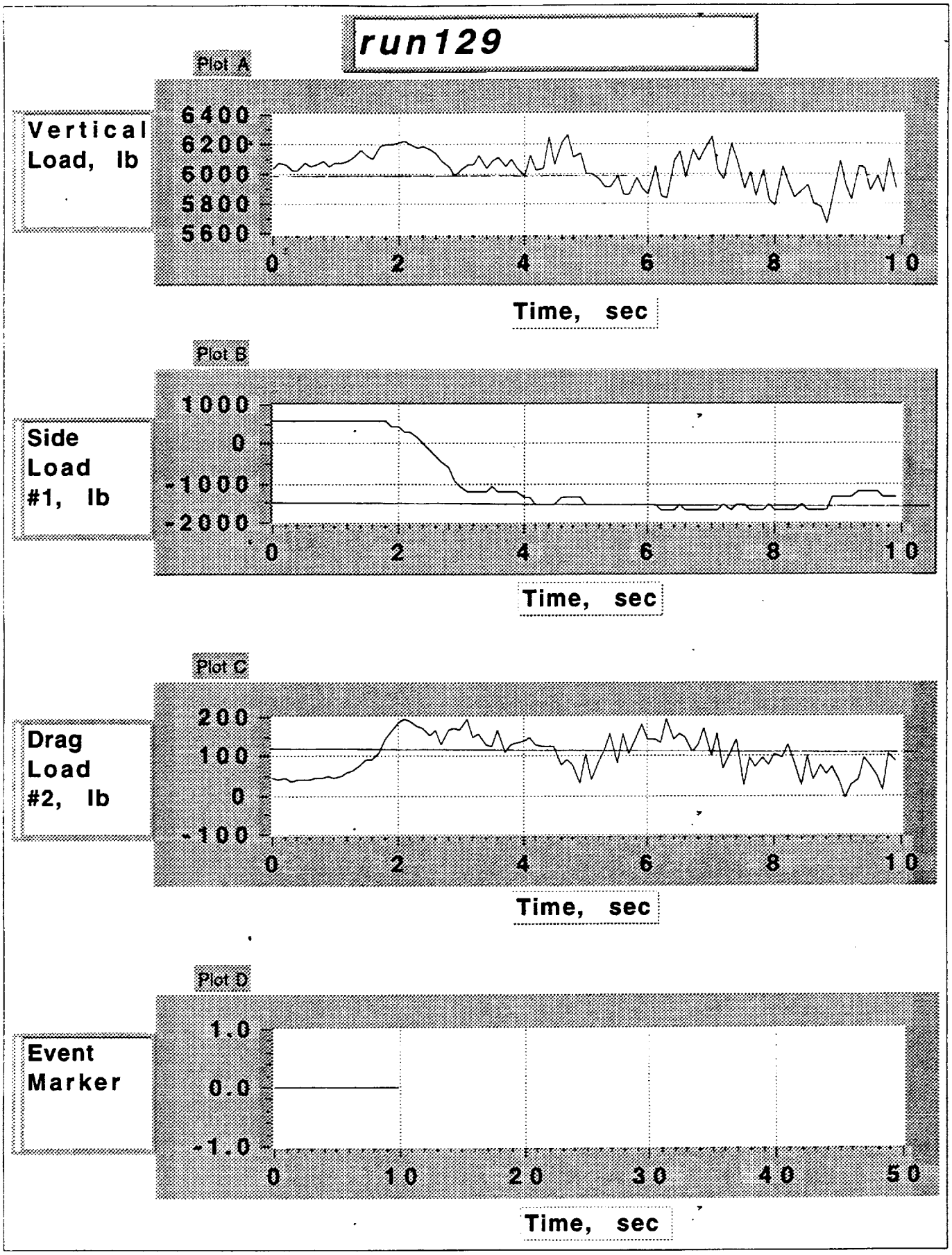

run124
Plot A
Vertical Load, lb
3200
3000
2800
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
500
0
-500
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
50
0
-50
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec


run125
Plot A
Vertical Load, lb
3200
3000
2800
2600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec


run126
Plot A
Vertical Load, lb
5000
0
-5000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
2000
1000
0
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
100
0
-100
-200
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec


run127
Plot A
Vertical Load, lb
3200
3000
2800
2600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec


run128
Plot A
Vertical Load, lb
1000
5000
0
-5000
-1000
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
500
0
-500
-1000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec


run129
Plot A
Vertical Load, lb
6400
6200
6000
5800
5600
0
2
4
6
8
10
Time, sec
Plot B
Side Load #1, lb
1000
0
-1000
-2000
0
2
4
6
8
10
Time, sec
Plot C
Drag Load #2, lb
200
100
0
-100
0
2
4
6
8
10
Time, sec
Plot D
Event Marker
1.0
0.0
-1.0
0
10
20
30
40
50
Time, sec

Appendix B

T-45 Nose and Main Gear Tire Footprints

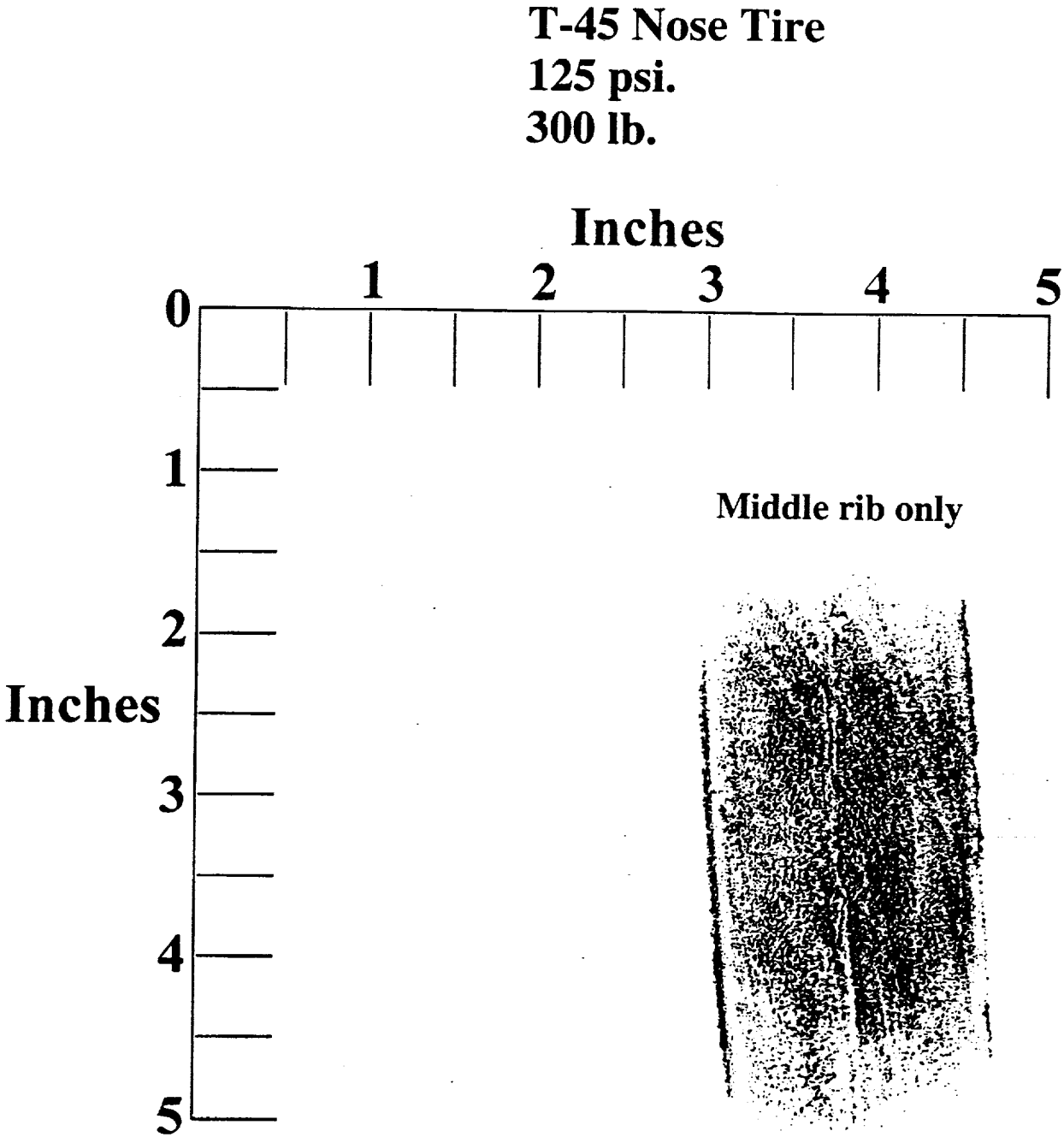

T-45 Nose Tire
125 psi.
300 lb.
Inches
0
1
2
3
4
5
Inches
1
2
3
4
5
Middle rib only

Figure B1

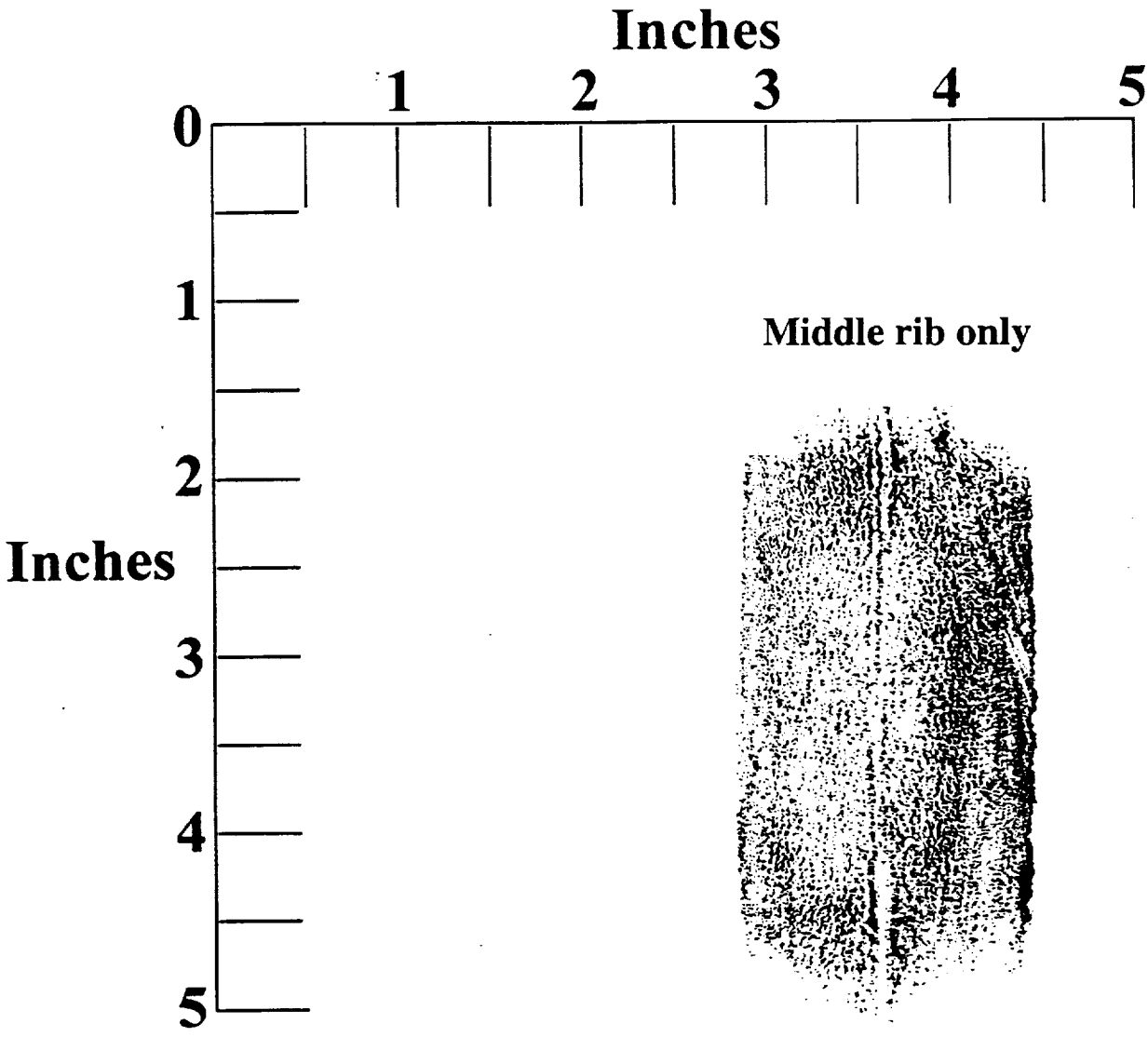

T-45 Nose Tire
125 psi.
600 lb.
Inches
1
2
3
4
5
0
1
2
3
4
5
Inches
Middle rib only

Figure B2

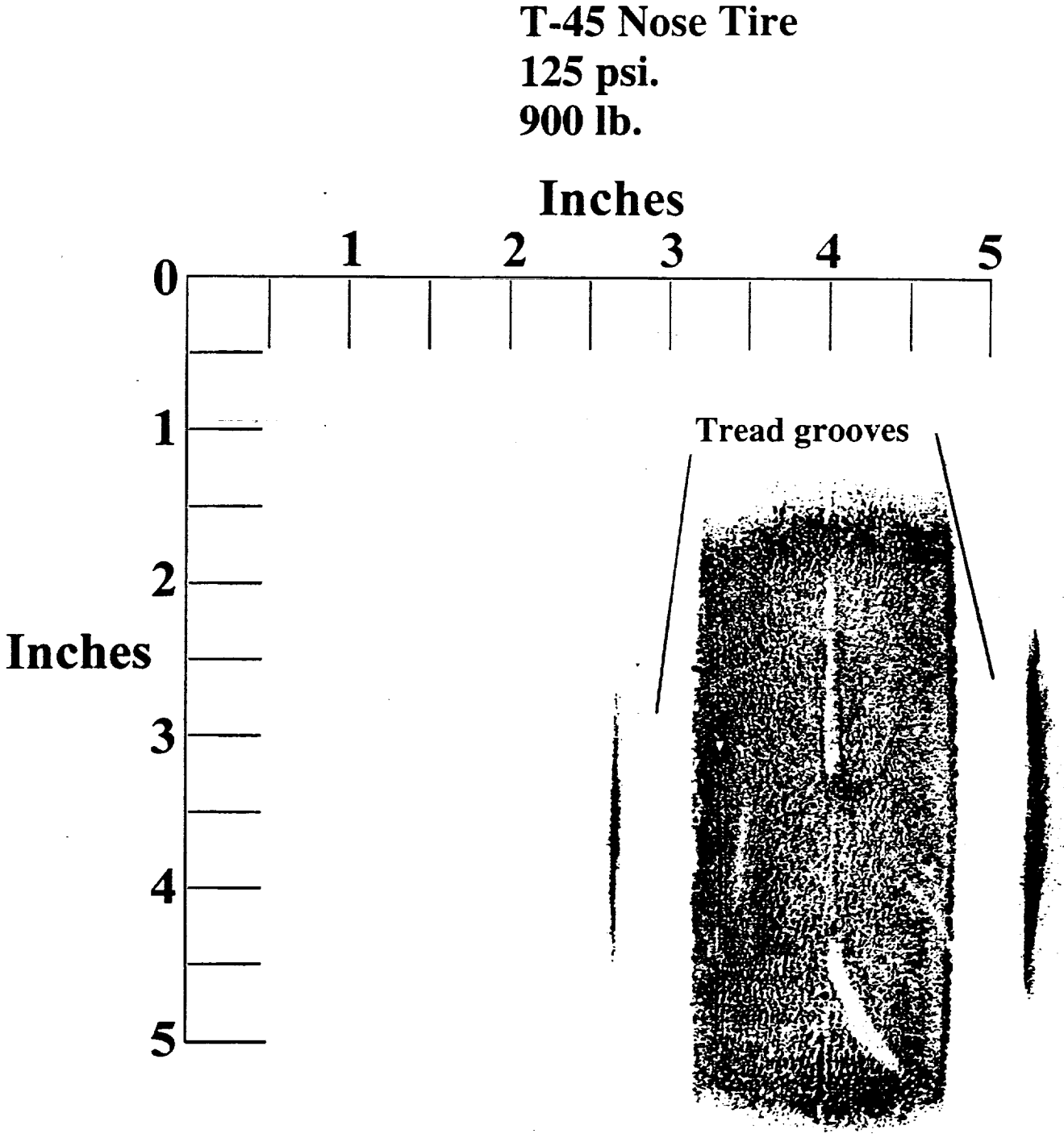

T-45 Nose Tire
125 psi.
900 lb.
Inches
1
2
3
4
5
0
1
2
Inches
3
4
5
Tread grooves

Figure B3

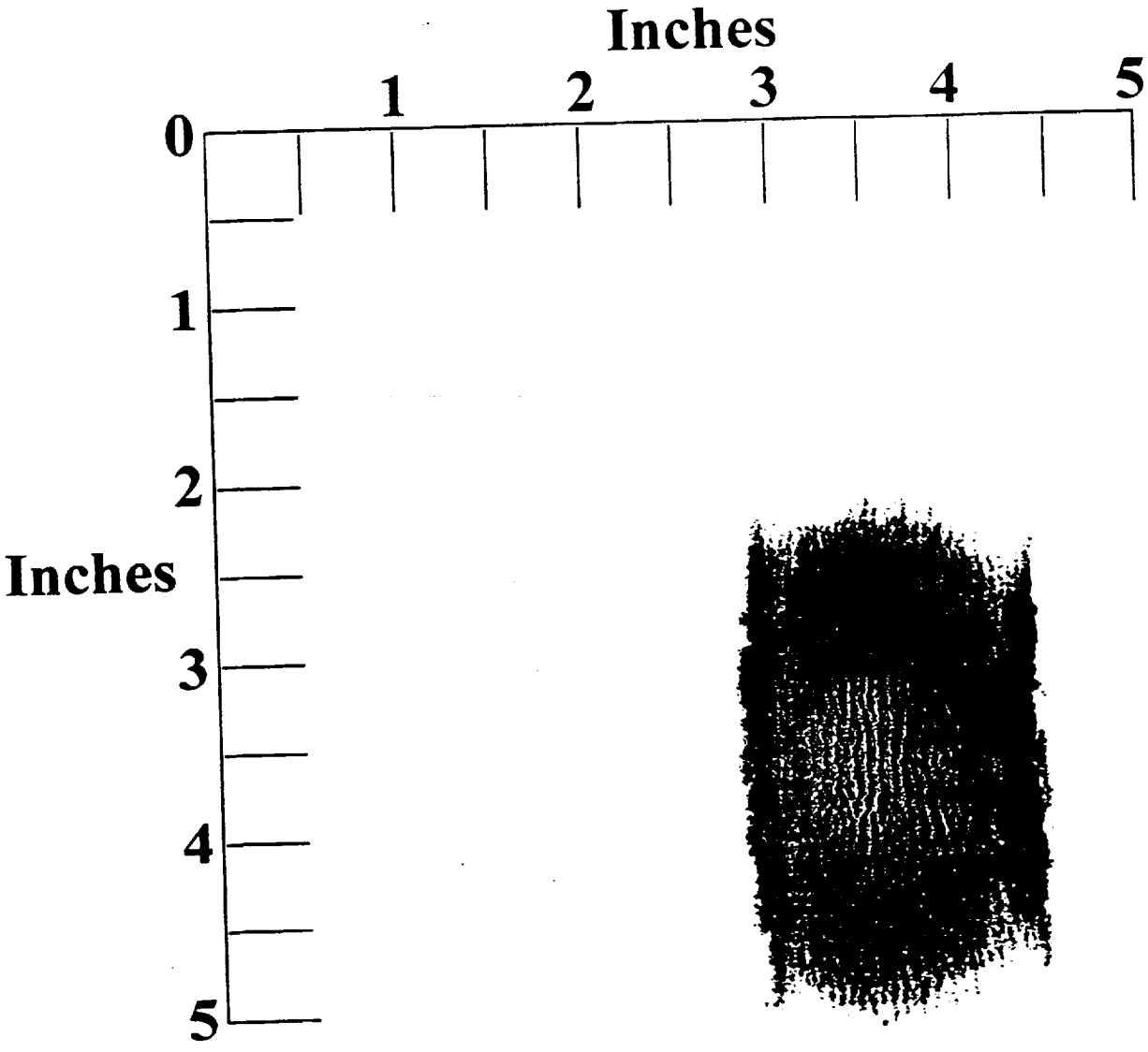


Figure B4

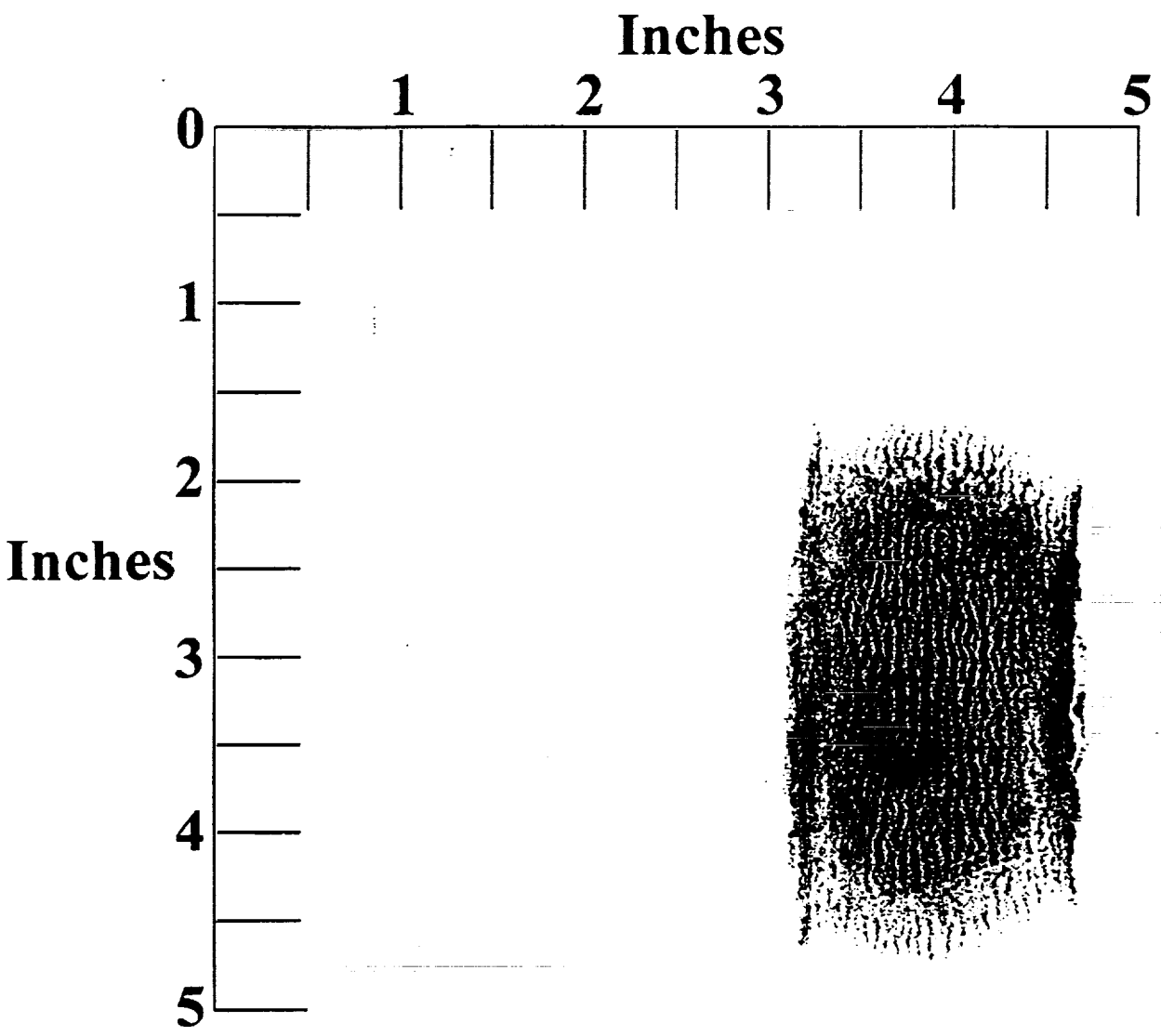


Figure B5

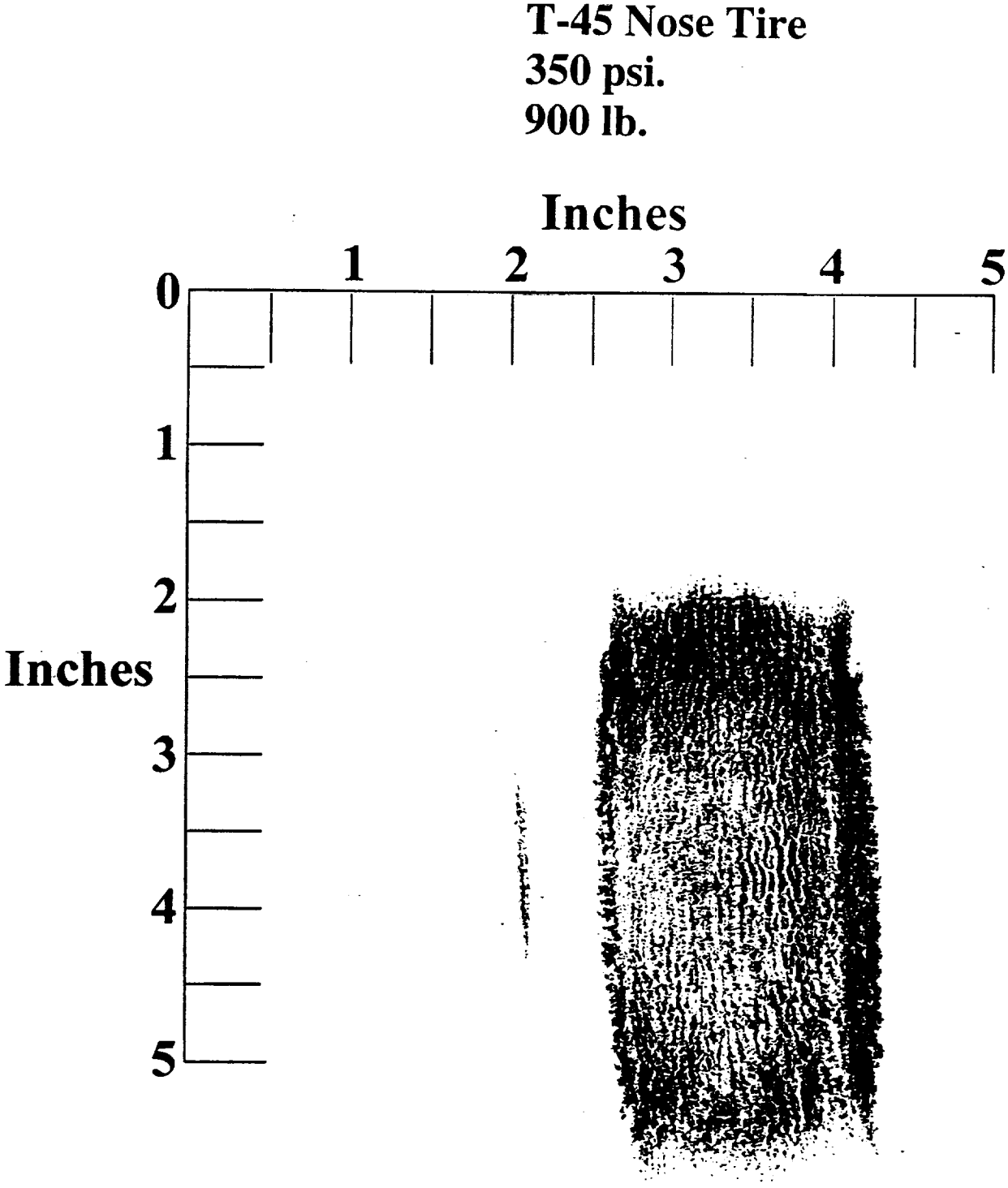


Figure B6

T-45 Main Tire
125 psi.
3000 lb.

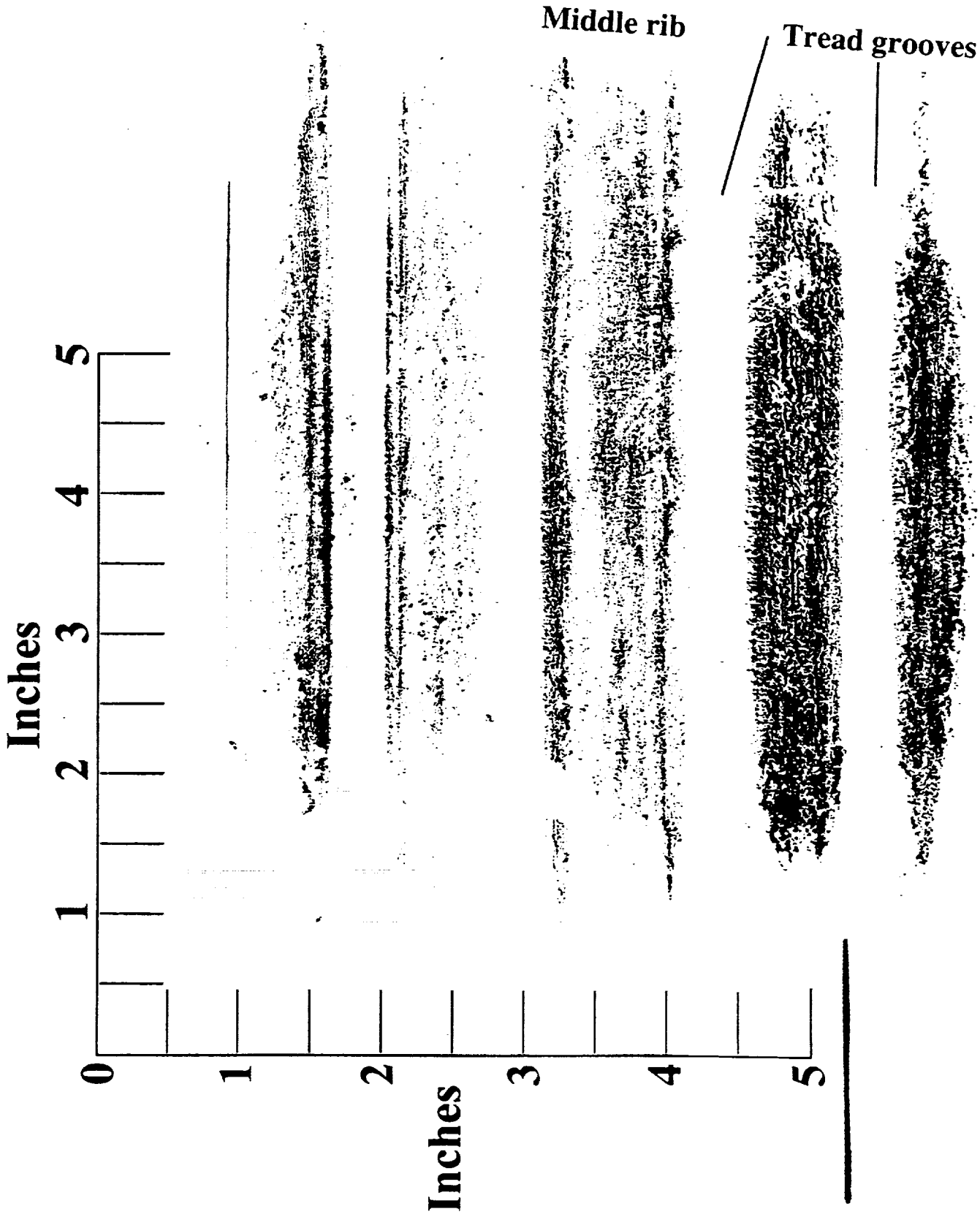


Figure B7

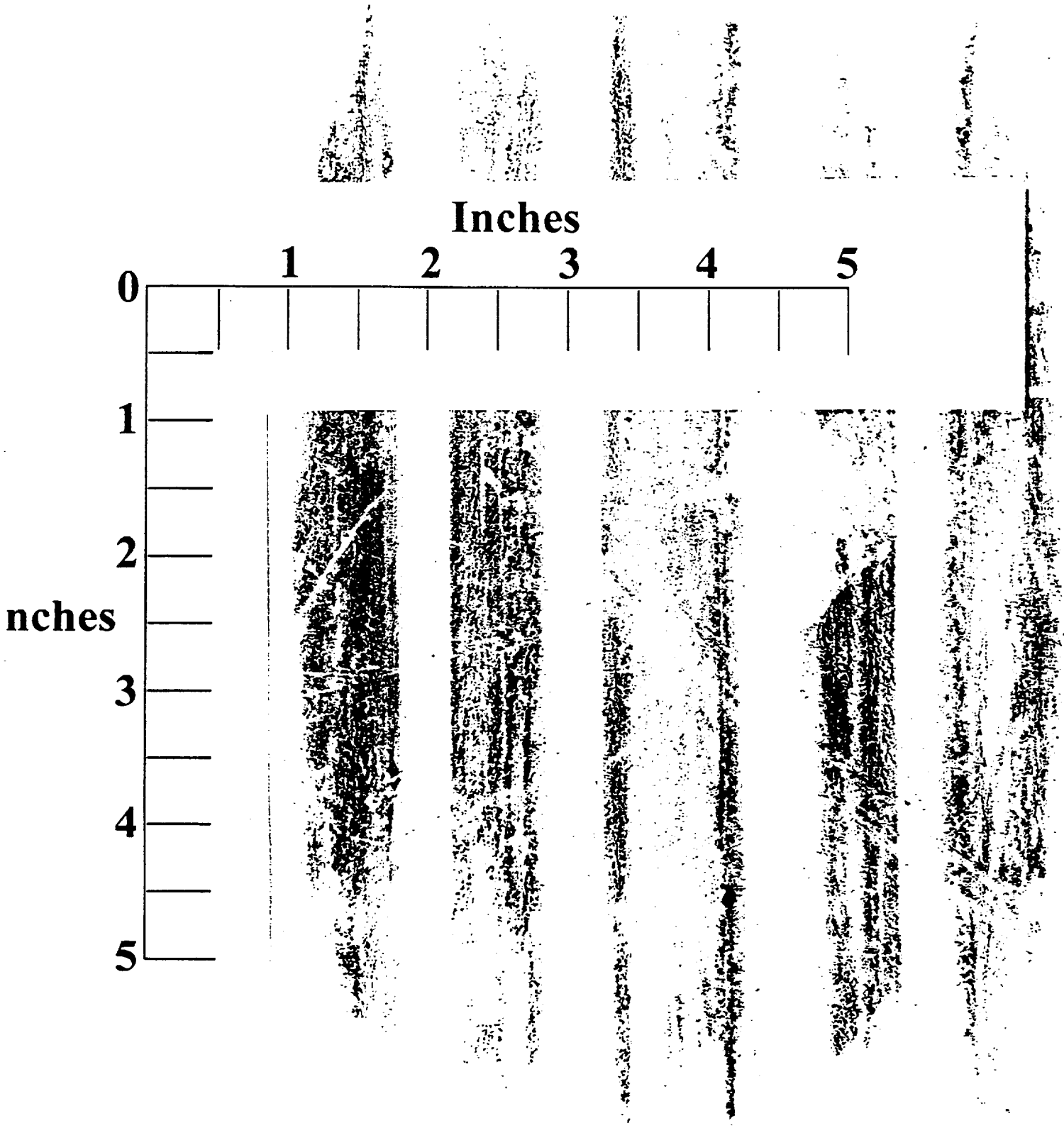


Figure B8

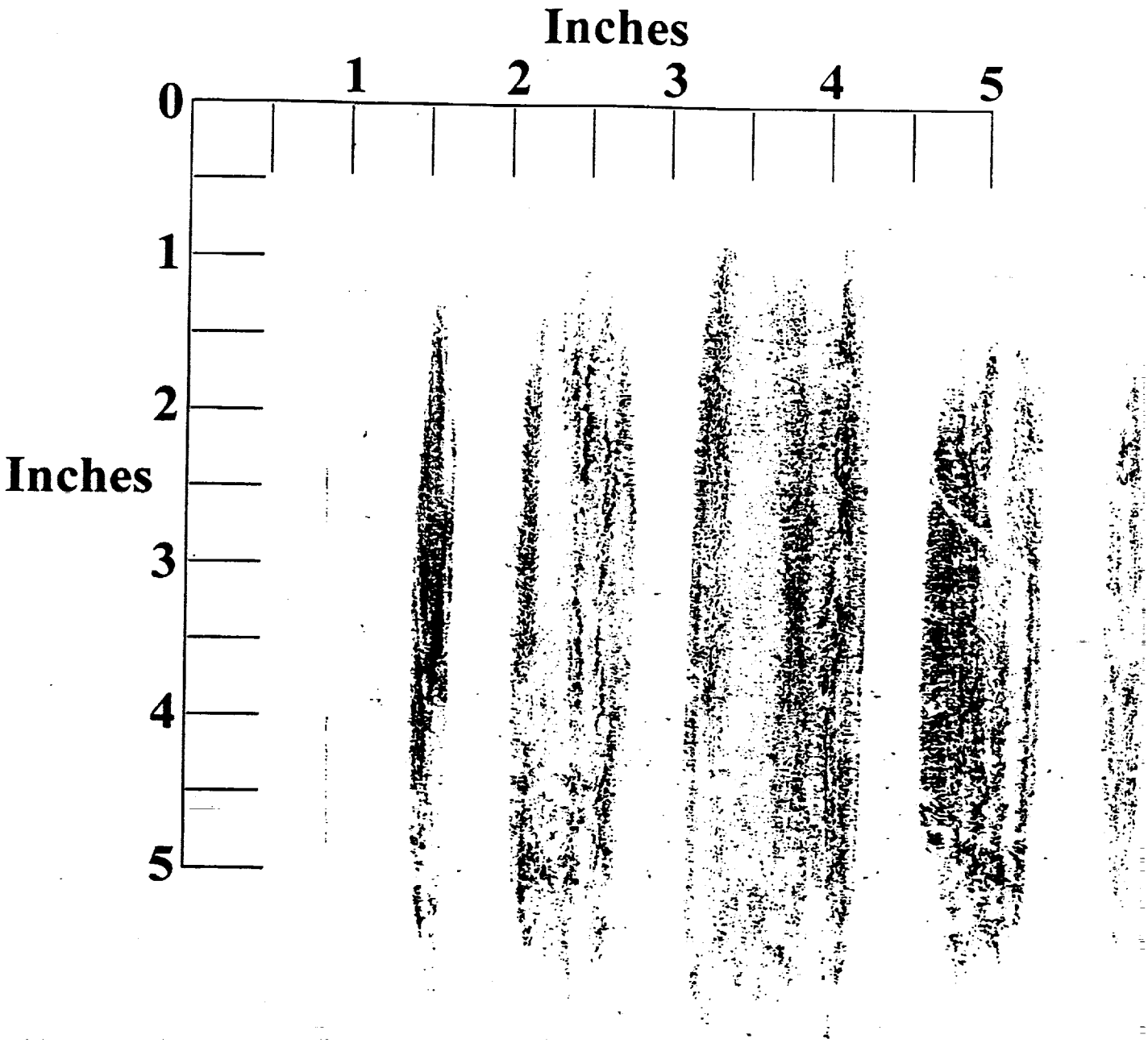


Figure B9

T-45 Main Tire
350 psi.
6000 lb.

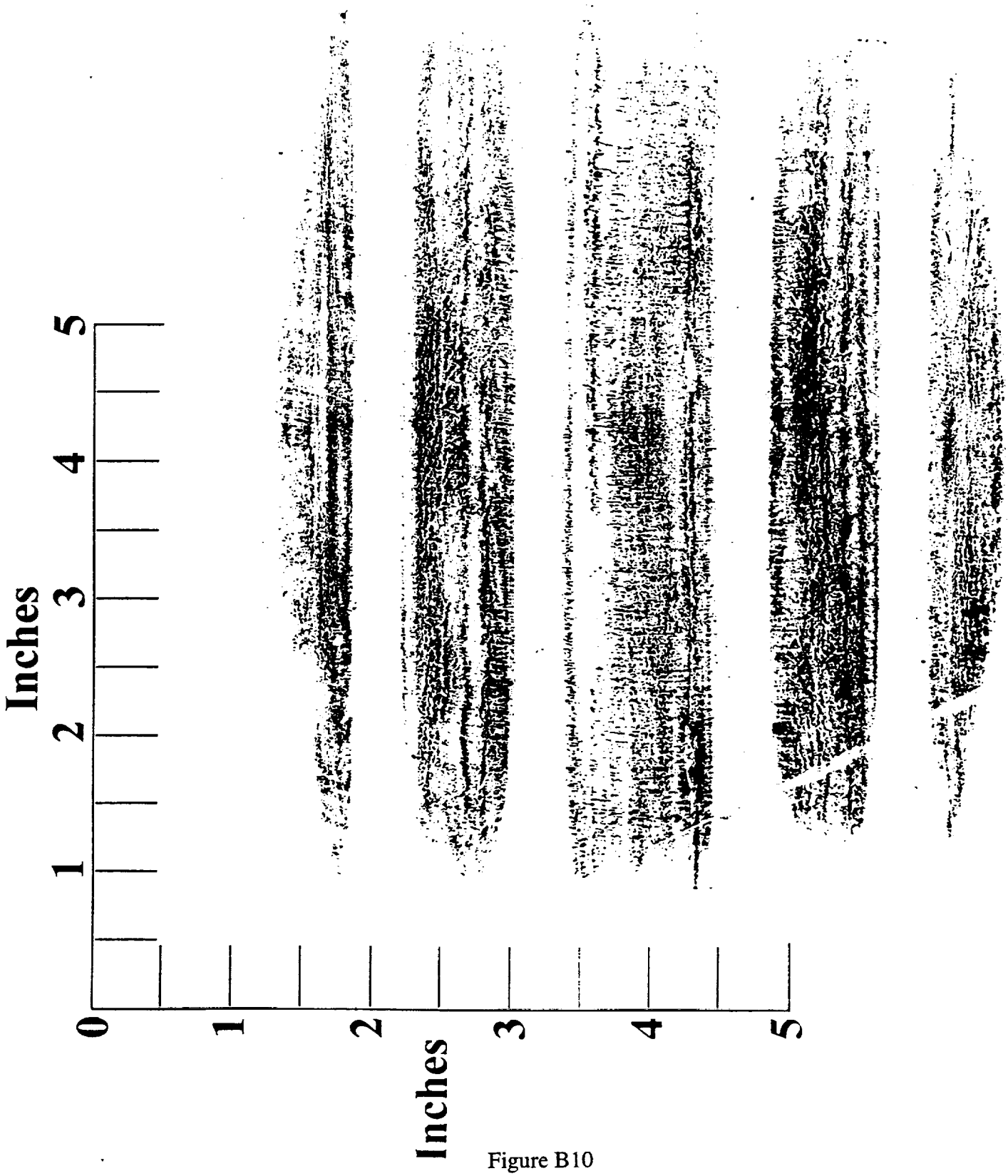


Figure B10

Appendix C

T-45 Nose and Main Gear Tire Cornering Behavior

T-45 Main Gear Tire Braking Behavior

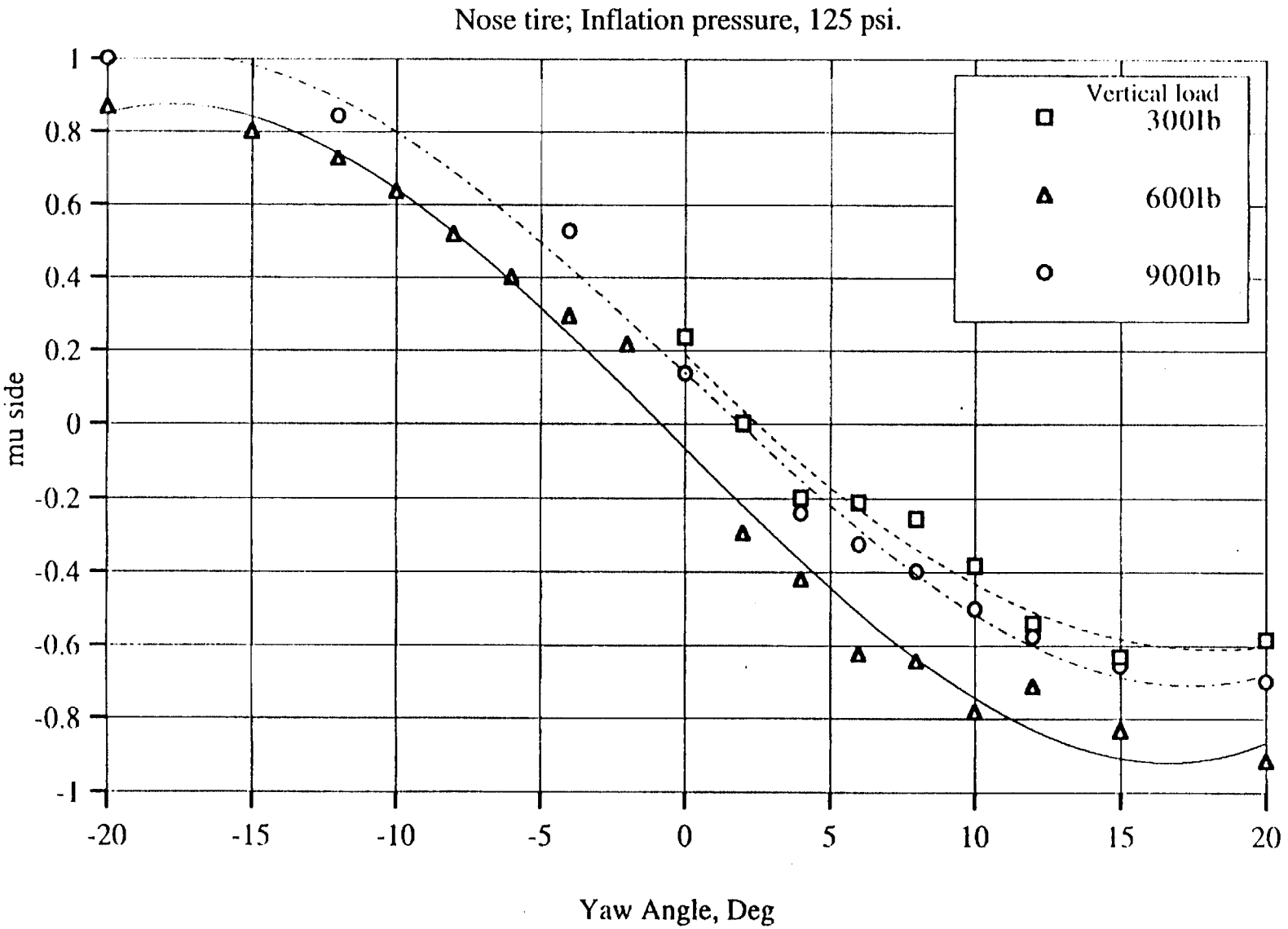

Nose tire; Inflation pressure, 125 psi.
Vertical load
300lb
600lb
900lb
mu side
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-20
-15
-10
-5
0
5
10
15
20
Yaw Angle, Deg

Figure C1

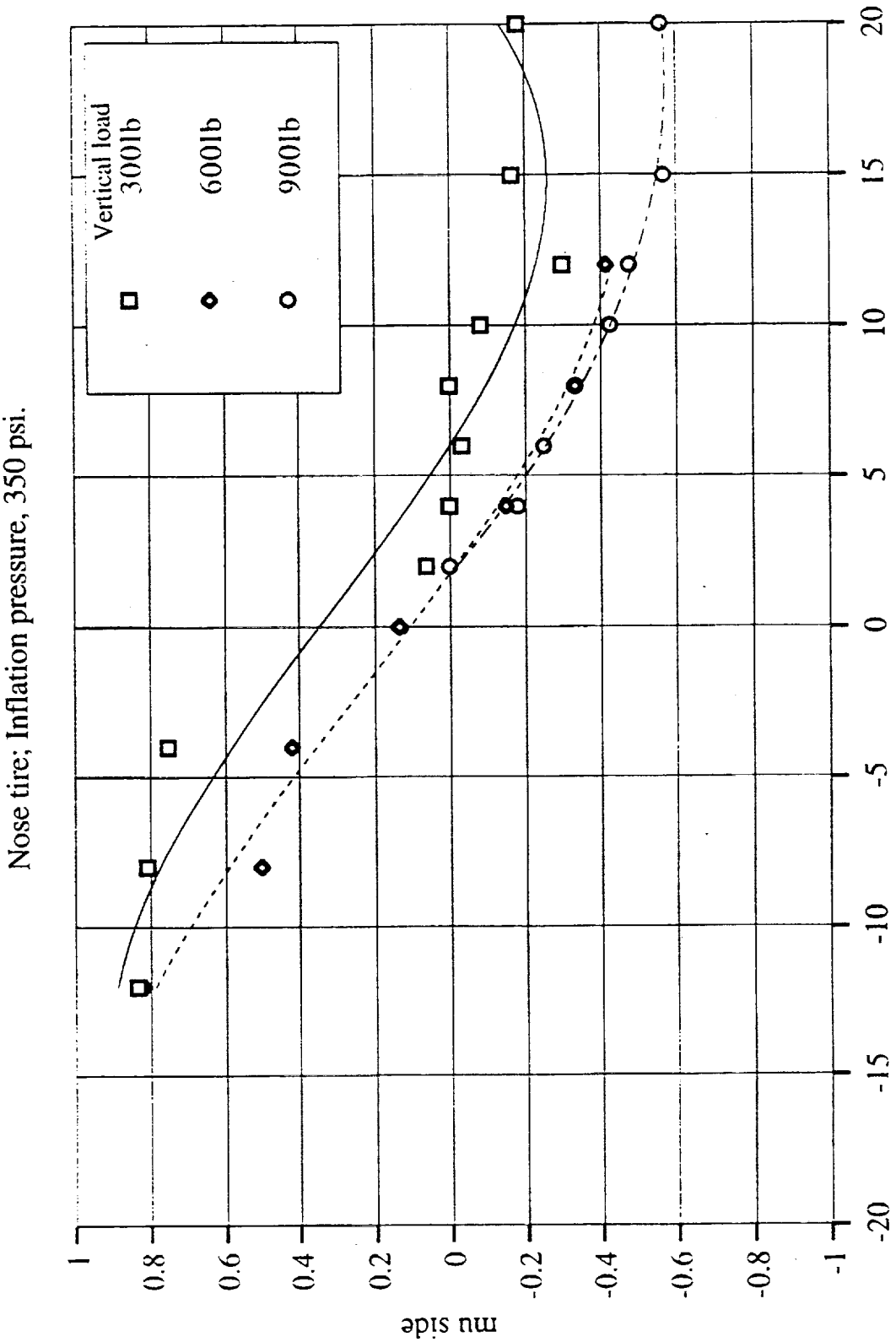
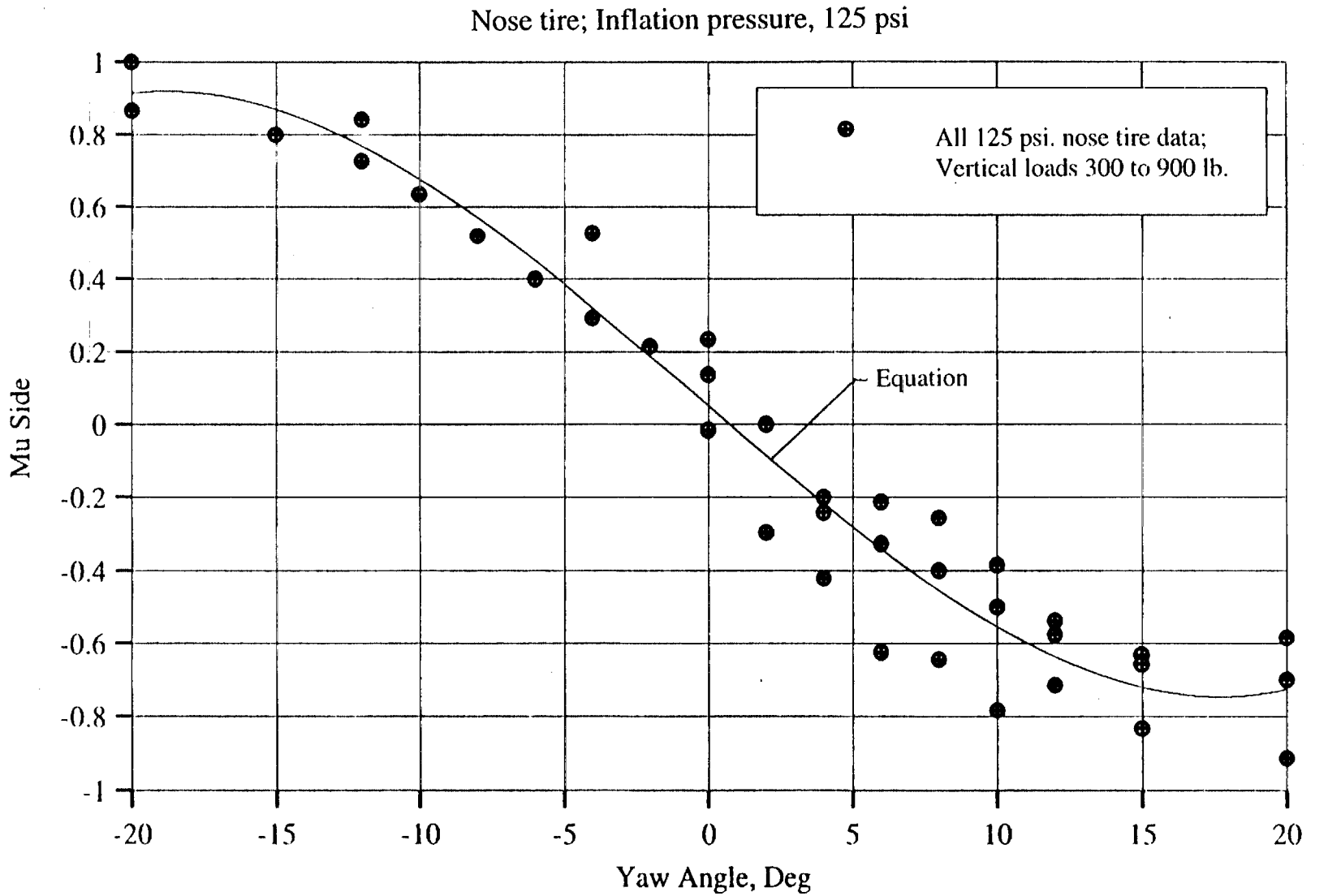

Nose tire; Inflation pressure, 350 psi.
Vertical load
300lb
600lb
900lb
mu side
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-20
-15
-10
-5
0
5
10
15
20
Yaw Angle, Deg

Figure C2



$y = 6.869E\text{-}05x^3 + 1.105E\text{-}04x^2 - 6.846E\text{-}02x + 5.103E\text{-}02$

Figure C3

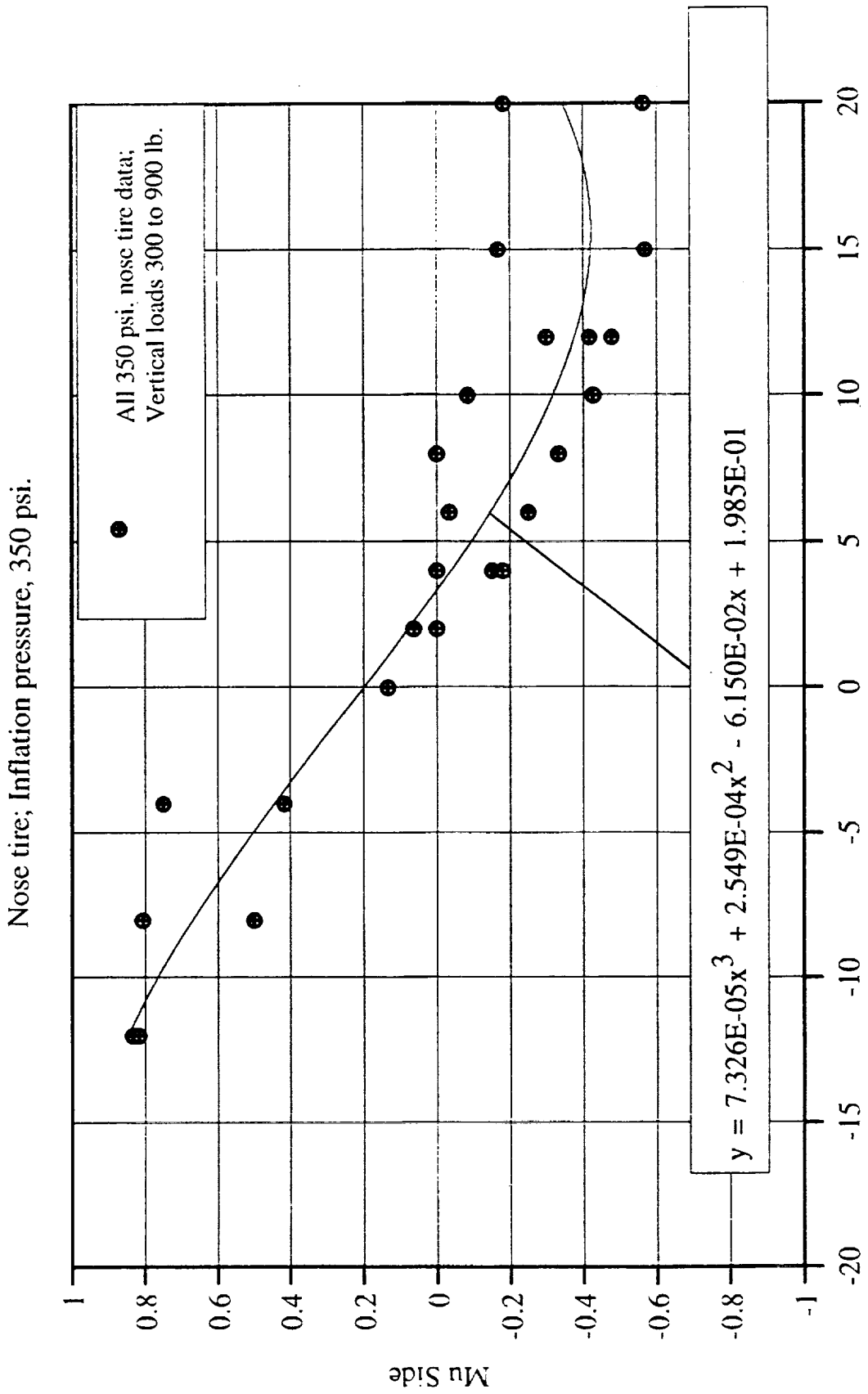

Nose tire; Inflation pressure, 350 psi.
All 350 psi. nose tire data;
Vertical loads 300 to 900 lb.
y = 7.326E-05x^3 + 2.549E-04x^2 - 6.150E-02x + 1.985E-01
Mu Side
Yaw Angle, Deg
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-20
-15
-10
-5
0
5
10
15
20

Figure C4

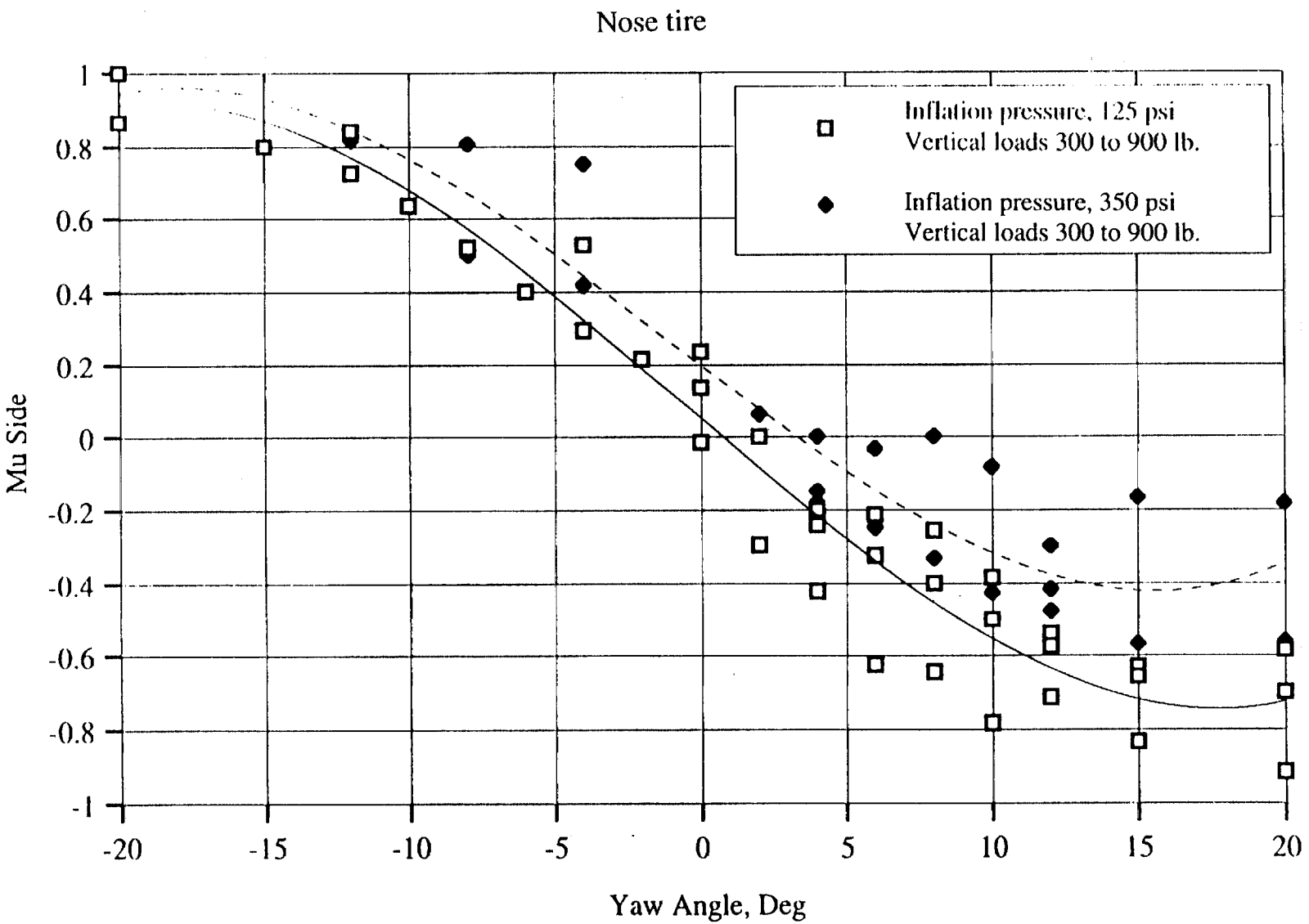

Nose tire
Inflation pressure, 125 psi
Vertical loads 300 to 900 lb.
Inflation pressure, 350 psi
Vertical loads 300 to 900 lb.
Mu Side
Yaw Angle, Deg
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-20
-15
-10
-5
0
5
10
15
20

Figure C5

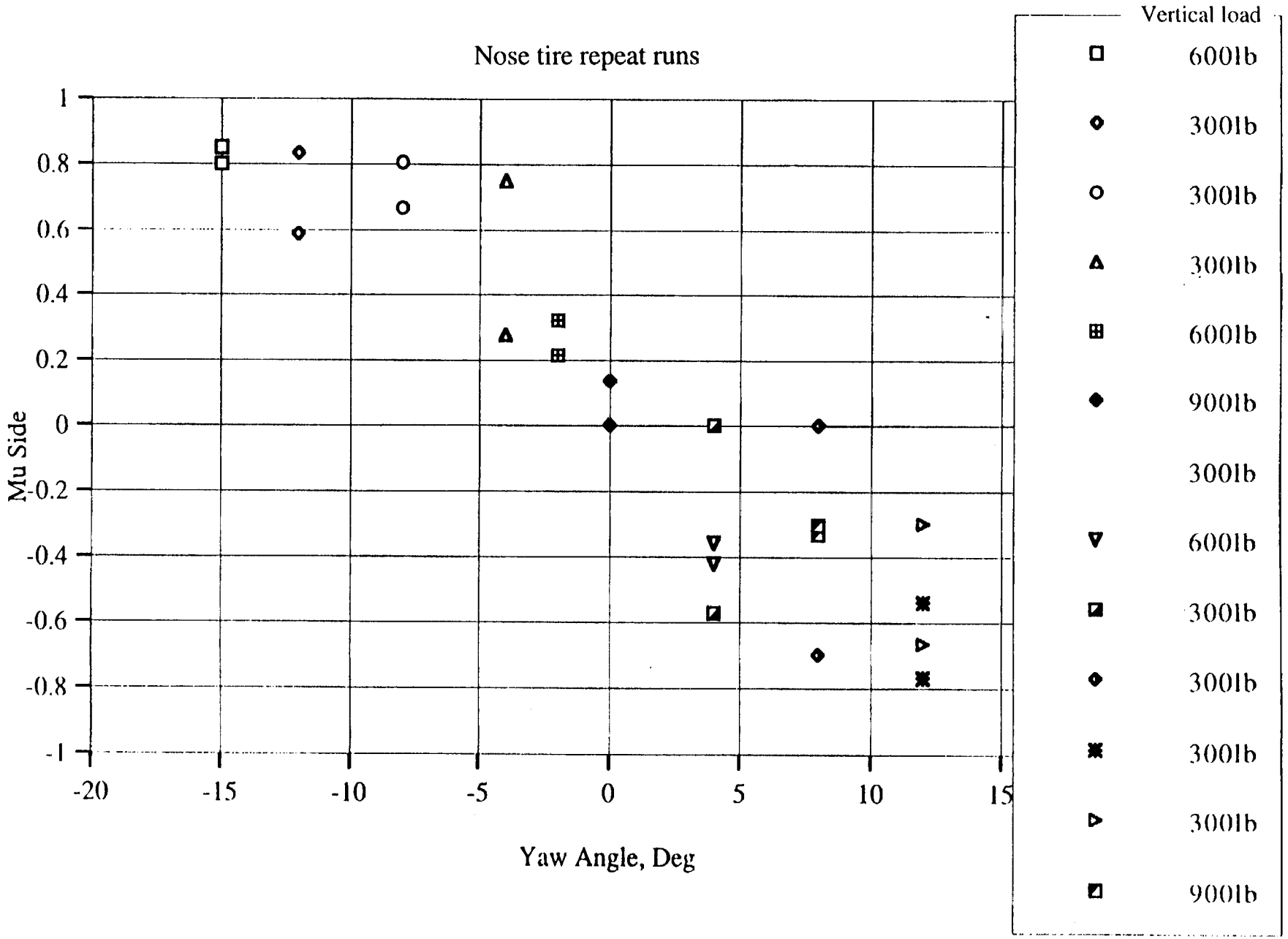

Nose tire repeat runs
Mu Side
Yaw Angle, Deg
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-20
-15
-10
-5
0
5
10
15
Vertical load
600lb
300lb
300lb
300lb
600lb
900lb
300lb
600lb
300lb
300lb
300lb
300lb
900lb

Figure C6

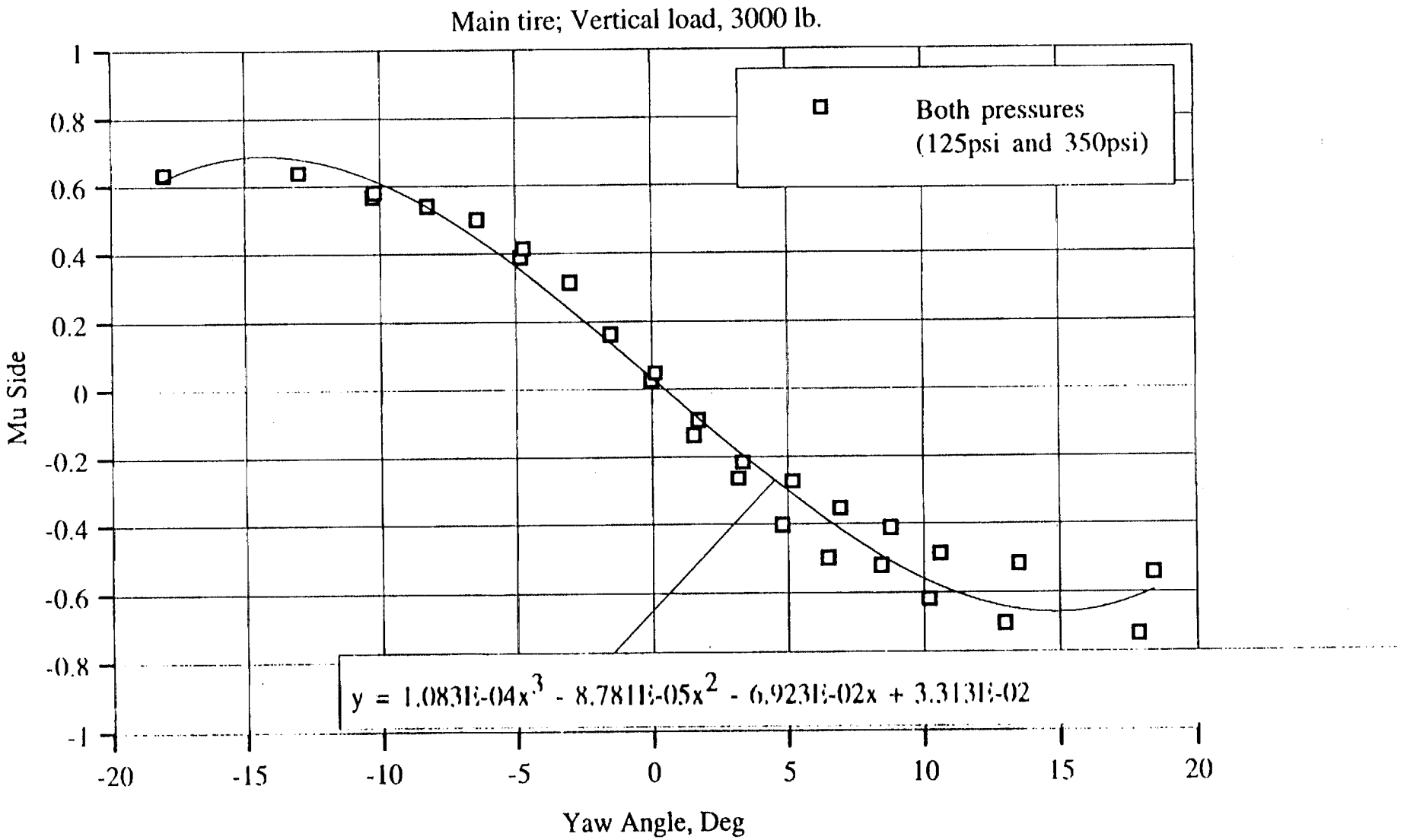

Main tire; Vertical load, 3000 lb.
Both pressures
(125psi and 350psi)
y = 1.0831E-04x^3 - 8.7811E-05x^2 - 6.9231E-02x + 3.3131E-02
Mu Side
Yaw Angle, Deg
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-20
-15
-10
-5
0
5
10
15
20

Figure C7

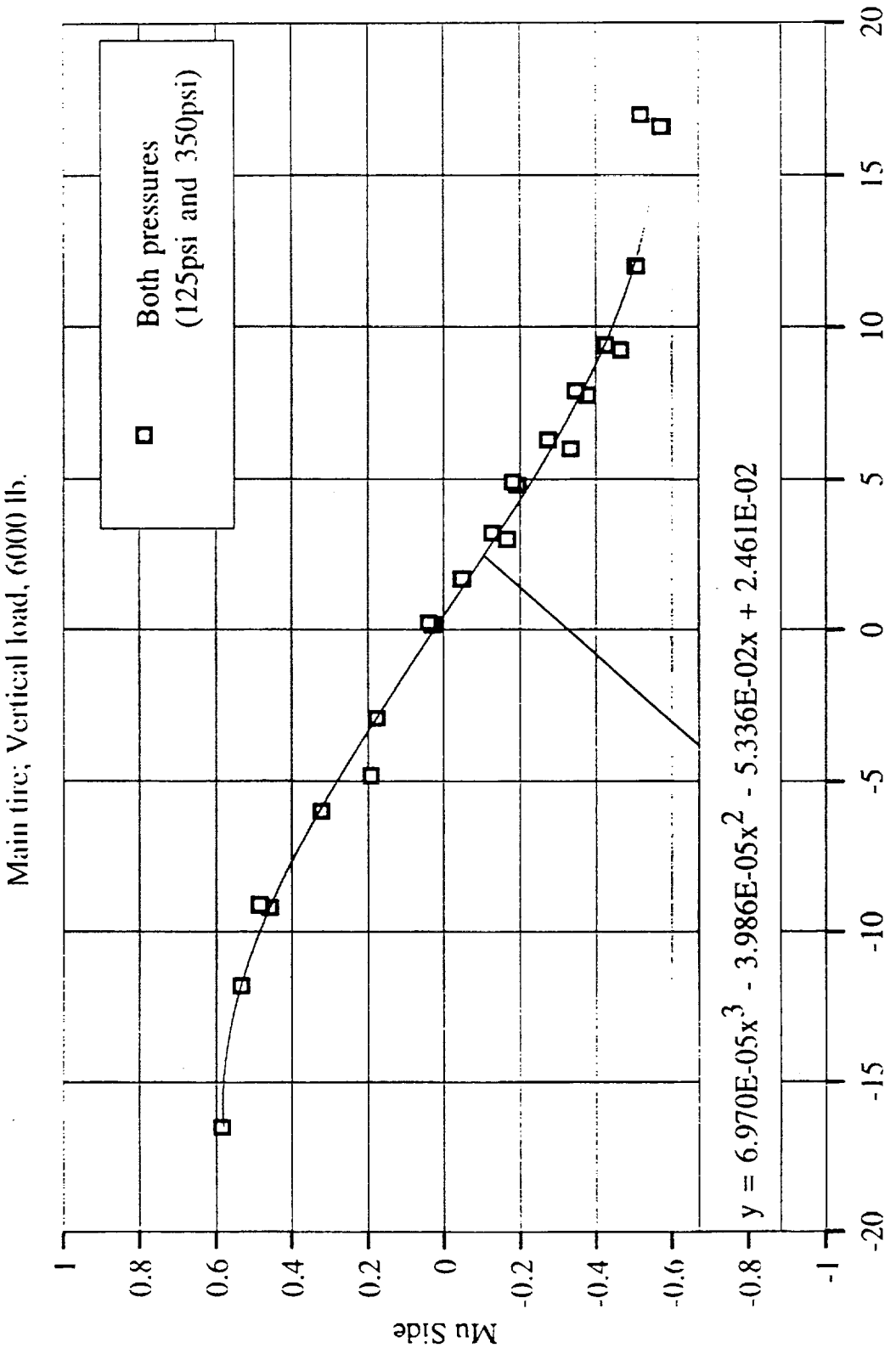

Main tire; Vertical load, 6000 lb.
Both pressures
(125psi and 350psi)
y = 6.970E-05x^3 - 3.986E-05x^2 - 5.336E-02x + 2.461E-02
Mu Side
Yaw Angle, Deg
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-20
-15
-10
-5
0
5
10
15
20

Figure C8

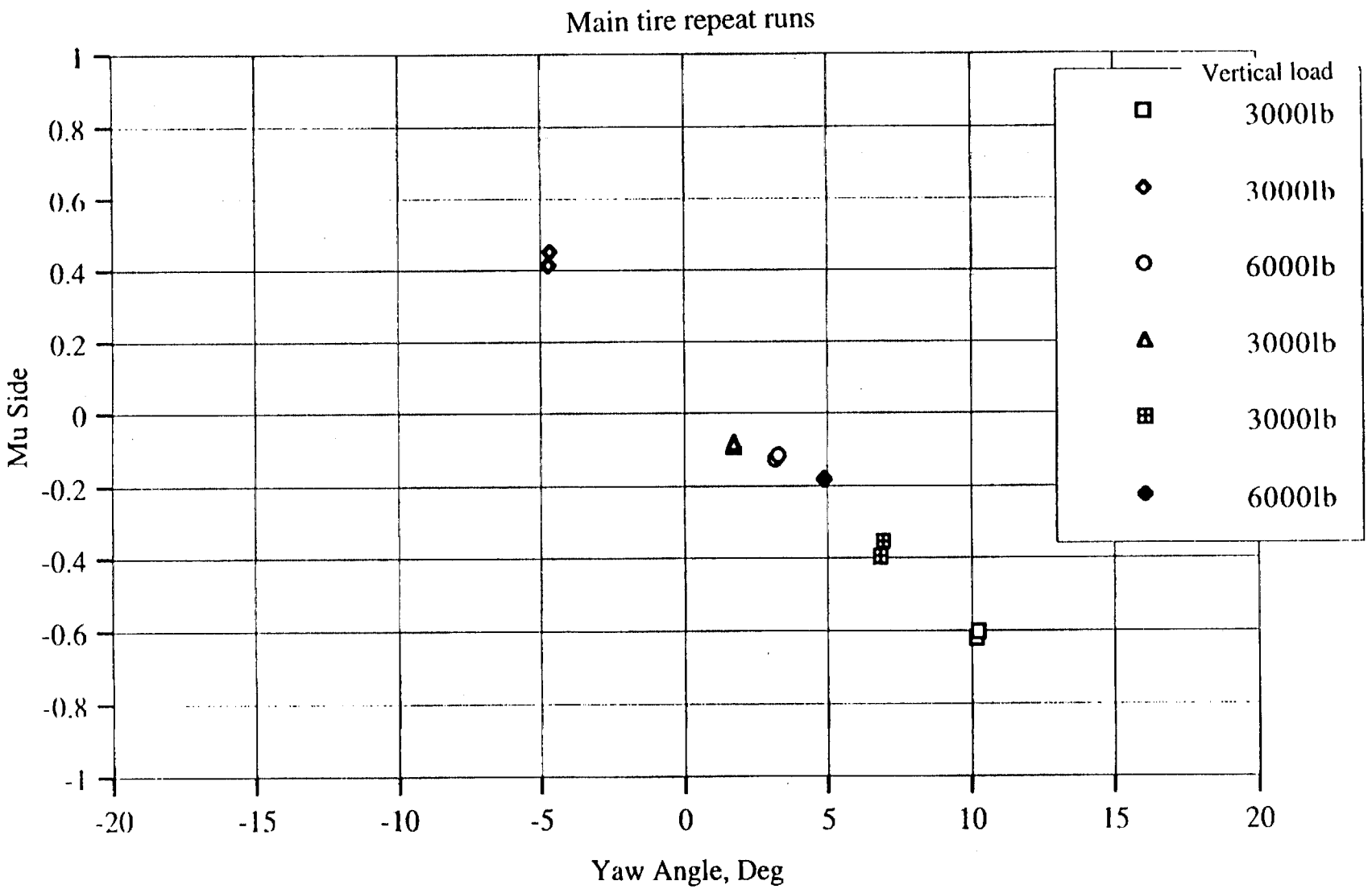

Main tire repeat runs
Mu Side
Yaw Angle, Deg
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-20
-15
-10
-5
0
5
10
15
20
Vertical load
3000lb
3000lb
6000lb
3000lb
3000lb
6000lb

Figure C9

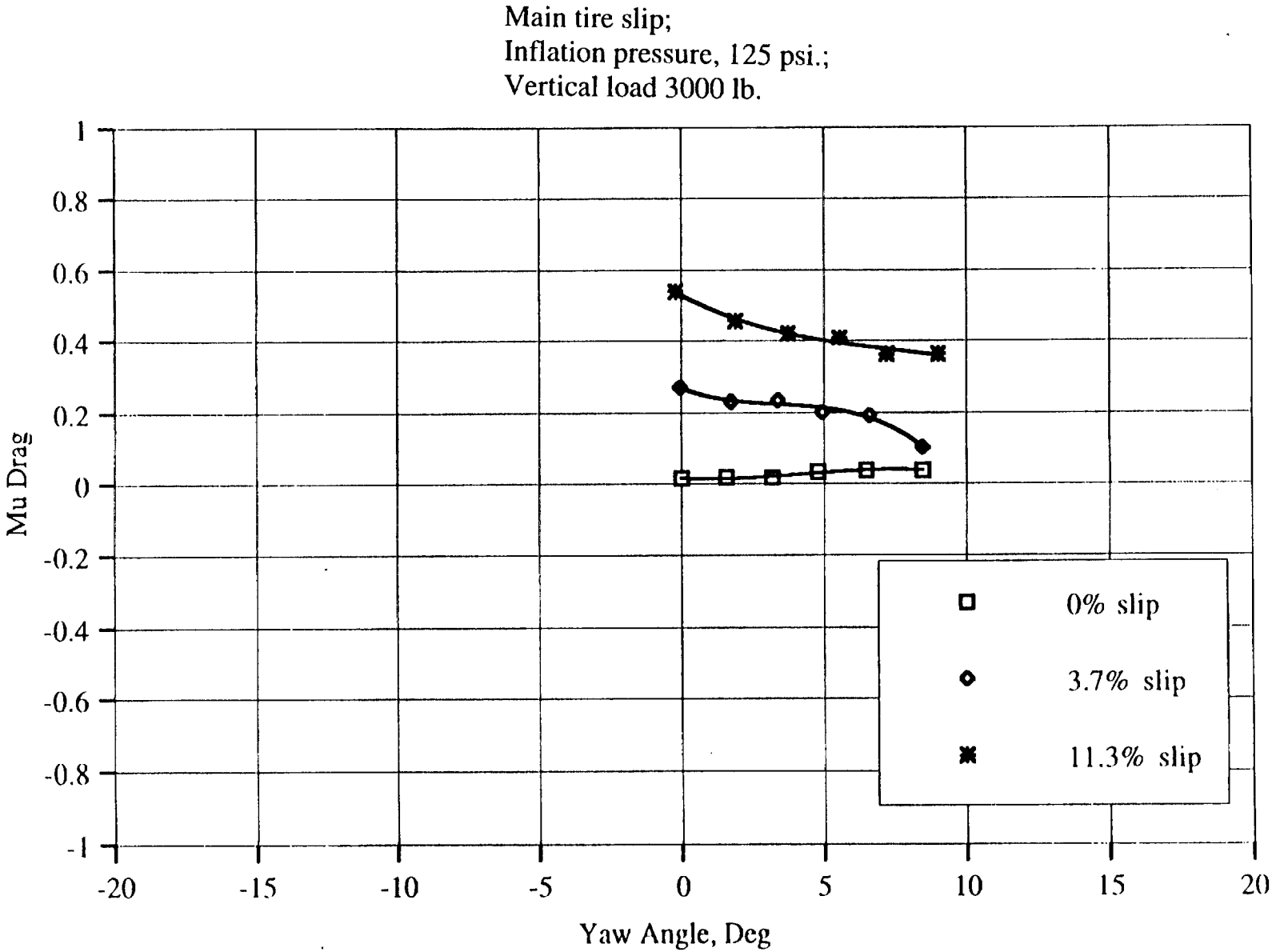

Main tire slip;
Inflation pressure, 125 psi.;
Vertical load 3000 lb.
Mu Drag
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-20
-15
-10
-5
0
5
10
15
20
Yaw Angle, Deg
0% slip
3.7% slip
11.3% slip

Figure C10

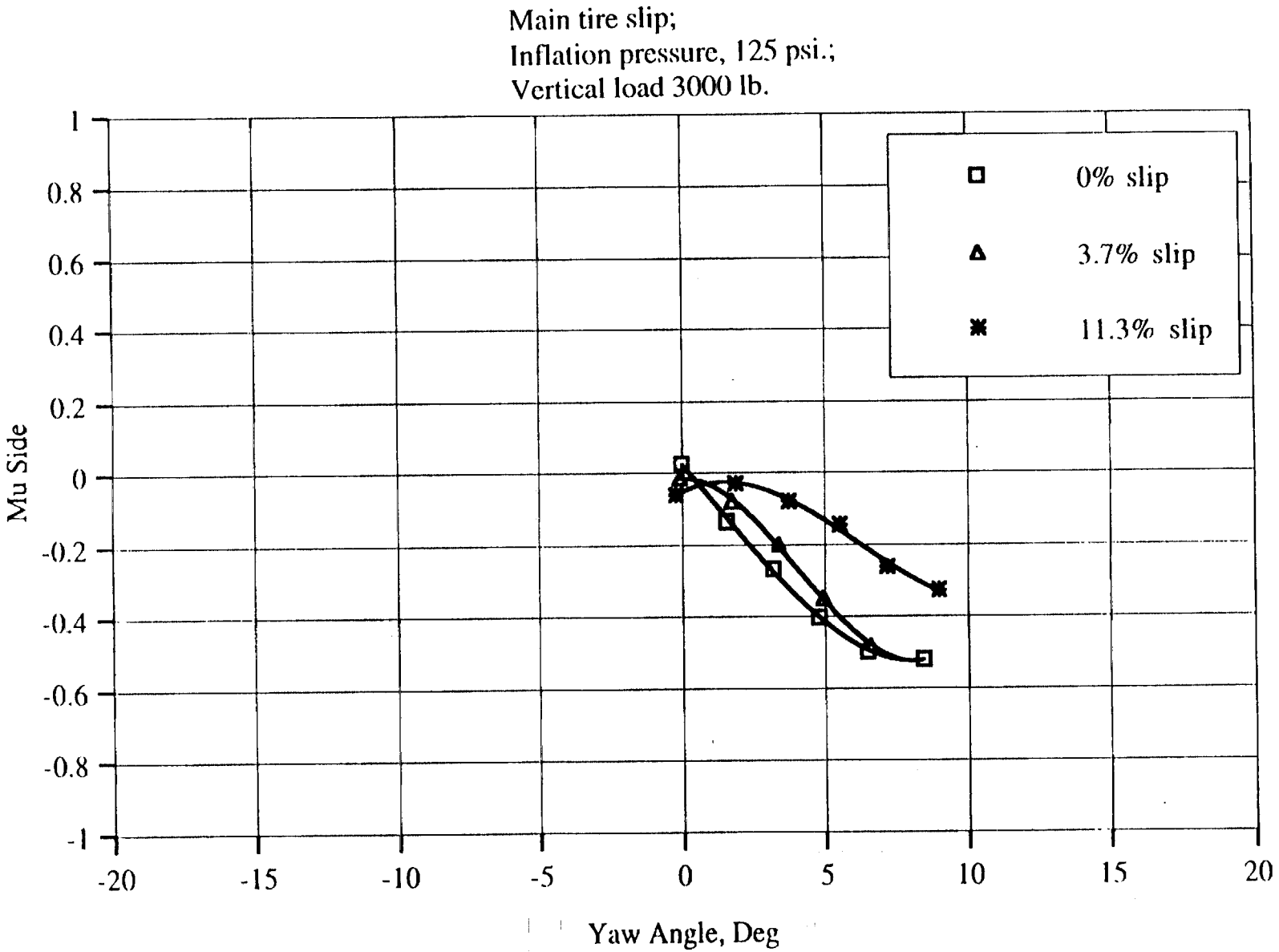

Main tire slip;
Inflation pressure, 125 psi.;
Vertical load 3000 lb.
Mu Side
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-20
-15
-10
-5
0
5
10
15
20
Yaw Angle, Deg
0% slip
3.7% slip
11.3% slip

Figure C11

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13. ABSTRACT (*Maximum 200 words*)
The T-45 Goshawk is a United States Navy Jet aircraft used primarily as a trainer. The aircraft design makes use of "off the shelf" hardware as much as possible and was found to have unusual directional control issues during ground operations. The aircraft was involved in numerous pilot-induced-oscillation incidents as well as observed to have unusual directional control reactions to failed main gear tires, a condition that is normally handled relatively easily by conventional aircraft steering control techniques. The behavior of the aircraft's tires had previously been modeled in simulators as a result of approximations provided in 40-year-old reference publications. Since knowledge of the true tire cornering and braking behavior is essential to modeling, understanding, and fixing directional control problems, the United States Navy requested assistance from the NASA Langley Research Center's (LaRC) Aircraft Landing Dynamics Facility (ALDF) to define the yawed-rolling mechanical properties of the T-45 aircraft tires. The purpose of this report is to document the results of testing the subject tires at the NASA LaRC ALDF in September 1998. Brief descriptions of the Instrumented Tire Test Vehicle (ITTV) are included to familiarize the reader with the ITTV capabilities, data acquisition system, test and measurement techniques, data accuracy, and analysis and presentation of the testing results.

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